

Chapter 11

Decision and Intervention Methodologies

Chapter 11 develops the meta-methodological architecture of decision and intervention within application-dominant Generative Relational praxis. Its role in Part IV is to translate the practical-philosophical architecture established in Chapter 10 into a configurable repertoire for diagnosis, practical orientation, evidence-to-commitment translation, decision, intervention, monitoring, evaluation, revision, and exit. The chapter's objective is methodological coordination under conditions in which knowledge, values, institutional capacities, action spaces, relations, and future consequences can remain incomplete or change during the practical process. The discussion combines conceptual reconstruction, methodological comparison, locally justified formalization, historical interpretation, participatory method, and intervention design. Domain-general scope is preserved until the final section, where the architecture is specified minimally for economic praxis and handed to Part V.

The chapter does not propose a universal decision procedure or a completed catalogue of GR methods. Different histories and relational fields can generate different practical orientations, criteria, evidence requirements, action spaces, institutional responsibilities, forms of intervention, and methodological combinations. A small reversible action can require a compact design, while a long-duration institutional transformation can require historical reconstruction, participatory governance, multiple models, staged authorization, independent monitoring, repair capacity, and residual obligations. The chapter therefore provides distinctions, interfaces, situation maps, candidate orientations, design dimensions, boundary conditions, and reopening rules through which locally appropriate methods can be composed. These resources remain provisional: later inquiry and practice may disclose additional situation dimensions, methods, or practical orientations that are more adequate to particular fields.

This meta-level orientation changes the status of several familiar decision objects. Goals and criteria are treated as historically situated and relationally conditioned practical objects rather than fixed exogenous inputs. Evidence epistemology and evidence-generation methods remain primarily in Chapter 5 and Part III; Chapter 11 addresses the narrower problem of how an inherited epistemic state can warrant practical commitment at a particular depth of action. Formal models and optimiza-

tion remain powerful local methods while their authority depends on the practical representation, normative inputs, historical transport, regime stability, and institutional use through which their outputs acquire consequence.

Sections 11.5 and 11.6 add two explicitly open meta-methodological resources. The first maps practical and epistemic situations along overlapping dimensions such as observability, probabilistic characterizability, model agreement, historical transport, dynamical condition, turbulence, possible critical transition, stakes, reversibility, time pressure, performativity, relational heterogeneity, power, and responsibility. The second identifies considerations and candidate practical orientations that can become salient under some configurations, including value co-articulation, relational viability and transformation, reversibility, option preservation, responsibility retention, review of self-reinforcing power, epistemic plurality, and proportionate commitment. Neither list is presented as exhaustive, and none of the candidate orientations is treated as an invariant GR good. Their relevance remains situated, contestable, and revisable.

A central methodological distinction concerns epistemic content and practical uptake. Observation, classification, interpretation, communication, recommendation, and institutional recognition can generate knowledge about a field. Their uptake can also change the field by altering standing, expectations, eligibility, access, coordination, allocation, or institutional response. Chapter 11 therefore treats epistemic events as possible participants in practical history. Monitoring, forecasts, administrative classifications, formal recommendations, and machine-mediated outputs can remain informational or become performative according to how they enter action.

Historical ordering provides another organizing principle. Practical time can be represented through partial-order relations among events when sequence and dependence are analytically important, while scalar time remains useful for duration, deadlines, rates, delays, and synchronization. Subjects can likewise be represented historically through relations, classifications, commitments, capacities, institutional positions, and transformations whose order contributes to present practical possibility. Partially ordered histories and related computational structures remain optional model forms under the book's ontological-suspension commitment.

The chapter maintains methodological pluralism throughout. Statistical forecasting, causal inference, dynamical systems, stochastic models, networks, higher-order relations, field models, operator representations, partial-order history models, agent-based simulation, optimization, and sensitivity analysis can each support particular practical questions. Historical reconstruction, legal and institutional interpretation, local knowledge, naturalistic expertise, narrative understanding, deliberation, participatory mapping, co-design, and contestability provide partially irreducible forms of access. Formal and natural-scientific methods can provide consistency, explicit assumptions, operationalization, computational comparison, and empirical testing where the field permits them; historical, interpretive, naturalistic, and participatory approaches can preserve forms of context, meaning, tacit recognition, and situated knowledge that are difficult to reduce to the same formal language. Each family also has limitations. Methodological composition therefore follows the practical object, available evidence, inferential task, consequences of error, responsibility structure, and required form of accountability rather than a fixed hierarchy of methods.

Decision analysis begins with evolving action spaces. Available actions can depend on resources, authority, legal conditions, institutional readiness, knowledge, coordination, prior commitments, and generated capacities. Scenario construction extends decision analysis into alternative histories, including counterfactual, adverse, transformative, branching, and long-horizon pathways. Robust and adaptive methods compare commitments across these histories while preserving uncertainty and the possibility that the action space itself changes.

One section is reserved for decision-making under critical-transition uncertainty. The chapter treats criticality as a model-relative and revisable practical hypothesis rather than a universal diagnosis. When defensible models admit possible qualitative transition, ordinary local inference can require qualification through regime-sensitive evidence, multiscale monitoring, model plurality, staged commitment, option preservation, and attention to intervention-induced transitions and incomplete reversibility.

Formal and quantitative models are then treated as a family of representations rather than a hierarchy of authority. Forecasting, causal modeling, dynamical and stochastic systems, network and higher-order models, field and operator representations, partial-order histories, history weights, agent-based models, simulation, optimization, sensitivity analysis, and model-risk analysis each answer different questions. Their practical force depends on assumptions, semantics, validation, and the relation between the model's validity domain and the commitment for which it is used.

Intervention methodology develops target, timing, scale, depth, and design while preserving their meta-level status. Intervention design is a situated composition drawn from a context-sensitive repertoire. Practical orientation, intervention object, mechanism, enabling conditions, history-space effects, observation, responsibility, revision, and exit can each become important, but their relevance and required resolution differ across interventions. Experimental and pilot intervention then provide one possible mode of practical learning within this broader architecture.

Monitoring, feedback, evaluation, repair, exit, and rollback make the architecture recursive. Observation can generate evidence and change behavior. Feedback can revise models, criteria, action spaces, or intervention sequence. Evaluation can concern immediate outcomes, relations, capacities, structures, distributions, option spaces, or historical consequences. Repair and compensation preserve responsibility after failure, while exit and rollback distinguish termination from historical restoration and keep residual obligations visible.

Before the chapter integrates these methods, Section 11.26 develops six illustrative boundary conditions of formal evidence-to-decision systems: evidential–normative underdetermination, responsibility retention, human-relational distance, temporal and historical transport, regime-sensitive reliability near critical transitions, and reflexive or performative feedback. The six conditions are examples rather than a completed list; other fields can disclose additional boundaries to formal closure. They show why even technically coherent decision systems can require institutional judgment and recursive revision. AI-assisted systems appear as one important contemporary instance, while their substantive economic and political-economic consequences remain the work of Chapter 18.

The chapter culminates in integrated intervention design. Integration is treated as a configurable and versioned coordination architecture rather than a mandatory pipeline. Diagnosis, historical-relational subject reconstruction, situation mapping, situated practical orientation, epistemic conditions, scenario construction, decision, intervention, monitoring, evaluation, model revision, action-space revision, and exit can be connected through explicit provenance, responsibility, and reopening relations. Different projects can omit, combine, reorder, deepen, or replace components according to their field and commitment profile. The method itself can become an object of revision when practice reveals that the inherited methodological repertoire is inadequate.

The final section prepares the transition to substantive Generative Relational Economics. It provides only the minimal domain-specification interface required to interpret general subjects, relations, resources, institutions, values, representations, histories, and interventions economically. Detailed economic architecture, allocation, generative value, and generative spacetime remain the work of Part V.

The chapter proceeds through six broad movements. Sections 11.1–11.4 establish the meta-methodological orientation through application-dominant method, diagnosis, situated evaluative formation, and epistemic conditions of practical commitment. Sections 11.5–11.6 map practical–epistemic situations and develop an open repertoire of situated considerations and candidate orientations. Sections 11.7–11.14 develop decision methods through evolving action spaces, alternative histories, robustness, adaptation, critical-transition uncertainty, formal and quantitative models, historical and interpretive analysis, and participatory methods. Sections 11.15–11.20 develop intervention construction through target, timing, scale, depth, situated design, and experimental or pilot intervention. Sections 11.21–11.26 develop the recursive lifecycle and identify illustrative boundary conditions of formal evidence-to-decision systems. Sections 11.27–11.28 integrate the architecture and specify its economic interface.

The objective of Chapter 11 is therefore to make application-dominant praxis methodologically articulable while preserving the epistemic, historical, relational, institutional, and normative openness established earlier in the book. The chapter supplies a meta-framework through which different methods can be selected, combined, revised, contested, and documented in relation to the practical field they address. Part V begins from this methodological inheritance and develops the substantive relational architecture of economic systems.

11.1 Methodological Architecture of Applied Praxis

Chapter 10 established application-dominant praxis as a domain-general architecture for consequential action under incomplete knowledge, plural values, unequal practical power, distributed agency, institutional dependence, and revisable closure. The role of the present section is to begin the methodological specification of that architecture. Its objective is to show how a practical orientation becomes a structured methodological task through the identification of decision objects and intervention objects, the selection and combination of methods, and the preservation of methodological revisability. The discussion proceeds through six movements: practical ori-

entation, decision objects, intervention objects, method selection, method combination, and revisability of applied methods. The method is architectural and translational. It starts from practical conditions already established at the level of praxis and asks what methodological form is required for those conditions to become inspectable, comparable, actionable, and revisable without losing their provenance.

The transition from applied praxis to method is consequential because a method does more than organize information. It specifies what will be observed, which distinctions will be stabilized, what counts as an alternative, how consequences will be represented, which uncertainties remain visible, whose knowledge can enter the analysis, and which forms of revision remain available. A practical orientation can therefore change as it is operationalized. A broad commitment to reduce vulnerability may become a decision among institutional designs, a sequence of local interventions, a threshold rule, a participatory process, or a portfolio of reversible experiments. Each methodological translation makes some features more legible while rendering others less central. Applied methodology should consequently preserve a reconstructable relation between the practical orientation and the methodological objects through which it is pursued.

This reconstruction should also preserve the possibility that epistemic activity changes the field it is intended to know. An observation can remain a typed readout from a modeled relational configuration, while recognition, classification, communication, institutional uptake, or another performative coupling can generate a distinct state-changing operation. Applied methods should therefore record whether an epistemic event merely updates a representation, alters a decision-maker's model, changes the relations among participants, modifies the practical action space, or does several of these things through differentiated pathways. This distinction becomes especially important when later evidence is produced in a field already reorganized by earlier observation or interpretation.

Decision and intervention objects should likewise remain historically relational. A practical subject can be represented, when useful, as a finite historical-relational substructure rather than as a point with a fixed preference vector. The project permits several computational realizations of this idea, including partially ordered event structures or labeled 2-complexes whose vertices, edges, faces, and labels preserve selected relations and historical events. Such representations are optional modeling resources rather than universal ontological commitments.

This chapter treats method as a family of organized procedures rather than as a synonym for formal modelling. Historical reconstruction, interpretive analysis, participatory mapping, statistical estimation, causal analysis, simulation, scenario construction, optimization, deliberation, monitoring, pilot intervention, evaluation, and adaptive revision can all perform methodological functions within application-dominant praxis. Their relevance depends on the practical object, the epistemic task, the temporal horizon, the distribution of consequences, and the institutional capacities through which the method will be used. The methodological question is therefore one of fit, combination, and governance across a practical lifecycle.

Definition 11.1 (Applied method). An *applied method* is a specified and revisable procedure, representational practice, analytical technique, participatory arrangement, or intervention protocol used to perform a practical methodological function within

Table 11.1: Methodological transition from applied praxis to organized method

Methodological component	Practical object	Primary function	Characteristic discipline
Practical orientation	Ends, values, affected positions, constraints, uncertainty, and temporal horizon	Preserve the direction and conditions of consequential praxis during operationalization	Orientation provenance, scope, plural values, and revision conditions
Decision object	A bounded commitment among practically reachable alternatives	Organize comparison, thresholding, authorization, and provisional closure	Alternative clarity, consequence structure, uncertainty, authority, and residual disagreement
Intervention object	A targetable relation, condition, capacity, institution, rule, or generative configuration	Organize purposive transformation through mechanisms and implementation pathways	Target-mechanism fit, scale, timing, safeguards, monitoring, and repair
Method selection	A methodological requirement generated by the practical situation	Choose procedures capable of performing the required epistemic or practical function	Fitness for purpose, feasibility, burden, uncertainty, contestability, and provenance
Method combination	A practical task requiring several partially irreducible forms of access or action	Coordinate differentiated methods across diagnosis, decision, intervention, and evaluation	Interface clarity, translation discipline, sequencing, triangulation, and preserved disagreement
Method revisability	A changing situation, evidence state, value configuration, or implementation trajectory	Govern alteration, replacement, retirement, or recoupling of methods over time	Versioning, revision triggers, continuity, comparability, and methodological memory

a consequential relational field.

Definition 11.1 is intentionally broad. A method can construct evidence, compare alternatives, disclose relations, organize participation, estimate consequences, stage an intervention, monitor change, or support revision. The same method can perform different functions in different practical architectures. A simulation used to explore possible trajectories performs a different role from the same simulation used to justify a threshold decision. A participatory process used to identify affected relations performs a different role from one used to authorize a collective commitment. Methodological description should therefore record function as well as technique.

Table 11.1 summarizes the six methodological transitions developed in this section. The table serves as an orientation map for the remainder of Chapter 11 rather than as a complete taxonomy of applied methods.

The architecture in Table 11.1 provides the chapter's starting discipline. Applied methods are selected for practical functions that arise from a situated orientation. Decision objects and intervention objects specify different kinds of practical work. Method combinations preserve differentiated forms of access while coordinating them. Revisability keeps the methodological architecture responsive to evidence and consequence. The remainder of the chapter develops these functions in increasingly concrete form, beginning with practical diagnosis in Section 284.

11.1.1 Practical Orientation

A practical methodology begins from an orientation whose structure is sufficiently explicit to guide method choice. Practical orientation includes the valued direction of action together with the problem formulation, affected positions, temporal horizon,

constraints, capacities, uncertainty, authority, and revision conditions that make the direction practically meaningful. It therefore carries more information than a goal statement. Two projects can share the same nominal goal while requiring different methods because their histories, relations, institutional capacities, risks, or reversibility differ substantially.

Methodological work should preserve this orientation as a living object rather than translating it immediately into one indicator or objective function. Premature compression can create a false appearance of precision. A plural practical orientation may contain a protected threshold, several compatible ends, unresolved value conflict, a requirement for participation, a preference for reversible commitments, and a long-horizon concern for future agency. A method that captures only the easiest measurable component can shift the practical orientation while leaving the shift unacknowledged.

Definition 11.2 (Practical orientation profile). A *practical orientation profile* is a structured record of the problem formulation, ends, relevant values, affected positions, practical horizon, constraints, capacities, uncertainties, authority relations, acceptable forms of commitment, and revision conditions that jointly orient an applied methodological process.

The practical orientation profile performs several functions. It provides a reference against which later methodological drift can be detected. It distinguishes changes in method from changes in practical purpose. It gives participants a common object for contestation when they disagree about ends, criteria, or scope. It also prevents later stages from treating a temporary operational proxy as though it were the original practical object.

Practical orientation has a temporal structure. Some ends concern immediate protection, others medium-term stabilization, institutional transformation, capability formation, or preservation of future options. The same intervention can support one horizon while weakening another. Methodological design should therefore identify which horizons are relevant and how they interact. A rapid decision method may be appropriate for immediate stabilization while a slower participatory and historical process develops the basis for longer-horizon institutional change. The methods can coexist when their functions and authority are differentiated.

Orientation also has a positional structure. A practical condition can appear differently from the standpoint of decision-makers, implementers, affected subjects, future maintainers, or actors who bear residual risk. Applied methodology should record these positional differences where they are materially relevant. This does not require that every practical judgment be reduced to a collection of viewpoints. It requires sufficient representation of the relations through which different positions encounter consequences, possess knowledge, and exercise agency.

A practical orientation can contain protected commitments. These may include rights, safety constraints, ecological limits, institutional duties, or participation requirements that should remain visible when methods compare alternatives. Treating every commitment as a tradable criterion can alter the normative architecture of the practical problem. Method selection should therefore distinguish between values that enter comparative evaluation and constraints that define the admissible region

of action.

Definition 11.3 (Orientation constraint). An *orientation constraint* is a practical condition that limits the admissible use of methods, alternatives, or interventions because violating it would materially conflict with a protected value, responsibility, right, safety requirement, institutional duty, or closure condition within the practical orientation.

Orientation constraints can themselves be revisable when their basis changes, but revision should be explicit. A methodological workflow becomes difficult to govern when a constraint is relaxed informally during implementation because it obstructs a preferred alternative. The profile should therefore identify who can authorize changes, what evidence is relevant, which affected positions should participate, and whether the change reopens the practical judgment more broadly.

The practical orientation profile is also the starting point for methodological pluralism. Different parts of the orientation can require different forms of access. Historical reconstruction may be required to understand how current constraints formed. Quantitative analysis may estimate the distribution of consequences. Interpretive work may clarify the meaning of an institutional category. Participation may reveal burdens or capacities weakly represented in administrative data. Simulation may explore future trajectories. A practical orientation therefore creates a set of methodological requirements rather than a single preferred method.

Proposition 11.4 (Orientation precedes methodological compression). *When a practical orientation contains materially relevant plural values, positional differences, uncertainty, or protected constraints, methodological compression into a single criterion or representation should follow explicit specification of those elements and preserve a record of what is retained, transformed, and omitted.*

Proposition 11.4 does not prohibit simplification. Practical action often requires bounded representations. The proposition establishes a provenance discipline: simplification should remain connected to the richer practical orientation from which it was derived. This becomes especially important when the simplified representation later acquires institutional authority.

The practical orientation profile therefore performs the first methodological translation of Chapter 10's praxis architecture. It converts a broad practical situation into an explicit set of methodological requirements while preserving plurality, history, position, and revisability. The next task is to identify the object of decision within that orientation.

11.1.2 Decision Objects

Decision methodology requires a bounded object of commitment. A practical situation can contain many possible questions: whether to act, which end to prioritize, which intervention to select, how much resource to commit, when to escalate, which threshold to use, whether to continue a pilot, or when to reopen deliberation. Each question constitutes a different decision object. Clarity at this level is essential because methods designed for one decision object can become misleading when transferred to another.

Definition 11.5 (Decision object). A *decision object* is a bounded practical commitment to be selected, authorized, deferred, revised, or rejected among a specified set of reachable alternatives under an identified consequence structure, uncertainty profile, temporal horizon, and responsibility arrangement.

A decision object contains more than alternatives. It includes the practical unit of commitment. A decision may concern a policy rule, an allocation, an intervention sequence, a trigger, a threshold, an institutional role, a continuation condition, or an exit pathway. The alternatives should therefore be formulated at the same practical level. Comparing a broad institutional transformation with a minor operational adjustment can create a misleading decision space if their scopes, horizons, and consequence structures differ substantially.

Decision objects also differ in temporal depth. Some are one-time commitments. Others are conditional or sequential. A provisional decision may authorize a first stage while reserving later stages for separate judgment. An adaptive pathway may specify several branches triggered by future observations. A method that treats a sequential decision as a one-time choice can obscure the value of learning and the preservation of options.

A decision object should therefore record its *commitment depth*: the degree to which selecting an alternative commits resources, authority, institutions, relationships, expectations, or future options. Commitment depth is related to scale and irreversibility, although the concepts are distinct. A small intervention can create deep institutional lock-in, while a large temporary mobilization can remain comparatively reversible. The methodological representation should follow the actual structure of commitment.

Definition 11.6 (Decision-object profile). A *decision-object profile* records the practical commitment under consideration, admissible alternatives, consequence dimensions, affected positions, temporal horizon, commitment depth, uncertainty, authority, evidential requirements, residual disagreement, and revision or reopening conditions relevant to the decision.

The profile also distinguishes decision alternatives from scenarios. An alternative is something actors can select or authorize. A scenario is a possible state or trajectory under which an alternative can be examined. Conflating the two can produce an analysis in which imagined futures appear as controllable options or controllable interventions are treated as external conditions. Chapter 11 therefore develops scenario construction separately from decision analysis.

Decision objects can be nested. A collective may first decide whether a condition warrants intervention, then select among intervention families, then choose timing, scale, target, and implementation rules. Each nested decision can have different participants and evidential thresholds. A single comprehensive choice can sometimes simplify coordination, yet decomposition can improve revisability when uncertainty is high. The methodological architecture should make the decomposition explicit so responsibility does not disappear between decision stages.

Decision objects can also be contested. Actors may disagree about whether the relevant decision concerns immediate mitigation, long-term transformation, resource allocation, procedural legitimacy, or preservation of future options. Such disagree-

ment concerns the constitution of the decision itself rather than merely the ranking of alternatives. A decision method should therefore permit revision of the decision object when the original formulation excludes a materially relevant commitment or affected position.

Definition 11.7 (Decision-object revision). *Decision-object revision* is a governed change to the scope, alternatives, consequence dimensions, horizon, authority, or commitment structure of a decision because the existing formulation no longer adequately represents the practical orientation or the situation in which commitment occurs.

Decision-object revision can occur before or after comparison begins. A method may reveal that all current alternatives violate an orientation constraint. Participation can disclose an omitted alternative. Historical analysis can show that the decision is framed at the wrong institutional level. Monitoring can reveal that the original object has been overtaken by changes in the situation. Revisability should therefore be designed into decision analysis rather than treated as evidence of methodological failure.

The decision object provides the unit around which decision methods are organized. It specifies what is being committed, compared, authorized, and potentially revised. The next subsection distinguishes this from the object of intervention, which concerns the configuration that praxis seeks to transform.

11.1.3 Intervention Objects

Decision and intervention are closely related but analytically distinct. A decision object concerns a commitment. An intervention object concerns what action is directed toward changing, sustaining, protecting, enabling, or constraining within the practical field. The distinction matters because one decision can authorize several interventions, and one intervention object can be approached through several different decisions and mechanisms.

Definition 11.8 (Intervention object). An *intervention object* is a specified condition, relation, capacity, constraint, institution, field configuration, rule, or generative process whose trajectory is intentionally addressed through practical action.

Intervention objects can be manifest or generative. A manifest intervention object may be an observable state requiring stabilization. A generative intervention object concerns the relations or conditions through which future states are produced. The distinction is important because changing a visible outcome can leave its generating relations largely intact, while changing a generative condition can produce delayed and distributed effects that are difficult to observe immediately.

The intervention object should therefore be represented at an appropriate depth. A recurring practical difficulty can be framed as an individual behavior, an interpersonal relation, an institutional routine, a structural constraint, an infrastructure, a distribution of capability, or a rule governing interaction. Each level suggests different methods and different risks. Chapter 11 later develops intervention target selection, scale selection, and intervention depth precisely because the intervention object should not be assumed from the first appearance of the practical problem.

Definition 11.9 (Intervention-object profile). An *intervention-object profile* records the target configuration, relevant relations and scales, hypothesized generative mechanisms, affected positions, enabling conditions, constraints, temporal dynamics, expected and unintended pathways, indicators of change, and conditions for adaptation, repair, or withdrawal.

The intervention-object profile creates a bridge between diagnosis and design. It should be sufficiently specific to support action while remaining revisable as implementation generates evidence. A target can change during intervention because the practical field responds. Actors adapt, institutions reorganize, capacities develop or erode, and new constraints become visible. The object of intervention can therefore be partly transformed by the intervention itself.

This reflexivity is especially important where the intervention changes categories, incentives, authority, or information. A measurement regime can alter behavior. A new institution can create actors whose later interests depend on the institution's continuation. A participatory process can generate collective agency that changes the implementation environment. A technical platform can reorganize dependencies. Methodological design should therefore distinguish between the intended intervention object and the broader relational changes generated through action.

Definition 11.10 (Intervention spillover field). An *intervention spillover field* is the set of materially relevant relations, positions, capacities, constraints, or institutional conditions altered by an intervention beyond the initially specified intervention object.

The spillover field should be monitored proportionately to consequence. It is rarely possible to observe every effect. The methodological task is to identify plausible pathways through which substantial distributed consequences could emerge and to maintain sufficient openness for unexpected effects to become visible. This is one reason intervention methodology requires interpretive, participatory, and historical forms of access alongside formal or quantitative monitoring.

An intervention object can also contain preservation as a legitimate practical aim. Intervention is sometimes associated with transformation, yet application-dominant praxis can seek to maintain a valuable capability, stabilize a fragile institution, preserve ecological or cultural continuity, protect a right, or prevent irreversible loss. In such cases the object is still intervention-relevant because action is directed toward sustaining a configuration against pressures that would otherwise alter it.

The relation between decision object and intervention object can now be specified more clearly. The decision object asks what commitment should be made under current conditions. The intervention object asks what configuration the commitment is intended to affect and through which practical pathways. A well-formed applied methodology keeps the two connected without conflating them.

Proposition 11.11 (Decision–intervention distinction). An *applied methodology gains practical clarity when the object of commitment and the object of transformation are specified separately and linked through an explicit account of mechanism, authority, implementation, and expected consequence.*

Proposition 11.11 prepares the later chapters on decision analysis and intervention design. It also provides the basis for method selection. Once the practical orientation,

decision object, and intervention object are sufficiently explicit, methodological requirements can be identified with greater precision.

11.1.4 Method Selection

Method selection is the process of matching practical methodological requirements to procedures capable of performing them under real institutional and temporal conditions. The relevant comparison is broader than technical accuracy. A method may be analytically sophisticated yet poorly suited to the practical horizon, unavailable data, institutional capacity, participation requirements, reversibility needs, or responsibility structure of the situation. Conversely, a comparatively simple method can be appropriate when it performs the required function transparently, rapidly, and with adequate uncertainty discipline.

Method selection begins by specifying function. A practical methodology may need to reconstruct history, identify actors, map relations, estimate causal effects, explore scenarios, compare alternatives, elicit values, detect distributional consequences, monitor implementation, identify failure, or support adaptive revision. The function determines what counts as relevant methodological performance.

Definition 11.12 (Method-selection criterion). A *method-selection criterion* is a practically relevant property used to assess whether a candidate method can perform a specified methodological function with adequate epistemic, temporal, institutional, participatory, and responsibility fit.

Method-selection criteria can include evidential appropriateness, representational fit, temporal responsiveness, scalability, burden, transparency, contestability, interpretability, data requirements, implementation capacity, uncertainty representation, sensitivity to context, and compatibility with later revision. Their relative importance depends on the practical object. A method used to trigger an emergency protective action may prioritize speed, conservative thresholds, and transparent failure modes. A method used to redesign a durable institution may require deeper historical reconstruction, broader participation, and stronger analysis of long-horizon consequences.

Method selection also includes the burden imposed by the method itself. Data collection can create privacy risks. Participation can demand time and emotional labor. Complex modelling can concentrate interpretive authority in a small technical group. Intensive monitoring can redirect organizational attention toward measured variables. An applied method is therefore part of the intervention environment and should be assessed for its own practical consequences.

Definition 11.13 (Method burden). A *method burden* is a materially relevant cost, exposure, dependency, exclusion, administrative demand, interpretive asymmetry, or opportunity cost generated by the use of an applied method itself.

Method burden can be justified when proportionate to the practical stakes, but it should remain visible. A method that produces highly precise estimates through a data regime that excludes important affected groups can distort the practical object even if the internal statistics are strong. A participatory process that repeatedly consults the same subjects without changing decision pathways can generate fatigue and distrust. A model that requires proprietary infrastructure can create future depen-

dence on a vendor or expert community. These effects belong to method selection because they shape the practical field in which later action occurs.

Selection should also consider *method failure modes*. Every method has conditions under which its output becomes weak, misleading, or difficult to interpret. Historical analogy can overstate transferability. Statistical models can be unstable under distributional change. Optimization can embed disputed objectives. Deliberative methods can reproduce power asymmetries. Scenario methods can narrow imagination through the framing of plausible futures. Simulation can generate false confidence when assumptions are weakly identified. Method selection should identify characteristic failure modes early enough for complementary methods or safeguards to address them.

Definition 11.14 (Method-selection record). A *method-selection record* documents the methodological function, candidate methods considered, selection criteria, principal assumptions, expected burdens, characteristic failure modes, institutional feasibility, uncertainties, reasons for selection, and conditions under which the method should be supplemented, revised, or retired.

The method-selection record supports both accountability and learning. It enables later evaluators to reconstruct why a method was reasonable under the conditions available at the time. It also prevents a method from becoming institutionally entrenched merely because it was used previously. Repeated use can be justified by demonstrated fit, yet routine should not substitute for renewed assessment when the practical object changes.

Method selection is therefore a practical judgment under methodological uncertainty. Often several methods are defensible, each illuminating different aspects of the problem. The appropriate response is frequently a governed combination rather than a search for one comprehensive method. The next subsection develops the architecture of such combination.

11.1.5 Method Combination

Complex practical objects commonly exceed the reach of any single method. Historical formation, current relations, causal mechanisms, local meanings, future trajectories, institutional capacities, value conflicts, and implementation dynamics can require different modes of access. Method combination organizes these partially irreducible contributions while preserving their epistemic differences.

A combination is stronger when each method has a defined function. Adding methods without specifying their relation can generate volume without integration. Several methods may repeat the same assumptions, rely on the same data source, or reproduce the same institutional blind spot. Methodological plurality becomes practically valuable when it creates differentiated access, checks assumptions, reveals disagreement, or supports distinct stages of the applied lifecycle.

Definition 11.15 (Method-combination architecture). A *method-combination architecture* is a governed arrangement of two or more applied methods whose differentiated functions, sequence, interfaces, evidential relations, authority, and revision pathways are explicitly specified within a common practical orientation.

Method combinations can take several forms. Methods can be *sequential*, where one produces an input for another. They can be *parallel*, where several methods examine the same practical object through different representations. They can be *nested*, where a local method operates inside a broader design. They can be *iterative*, where outputs from one method revise the conditions of another. They can also be *adversarial* in a constructive sense, where different methods or teams are organized to challenge assumptions and identify failure conditions.

Combination requires interface discipline. A qualitative category can be translated into a quantitative variable, but the translation can narrow meaning. A simulation can use a historical estimate as a parameter, but the parameter may depend on a context that does not transfer. A participatory finding can modify an evaluation criterion, but the process through which voice becomes formal weight should remain explicit. Methodological interfaces are therefore sites at which practical meaning can change.

Definition 11.16 (Method-interface transformation). A *method-interface transformation* is a materially relevant change in representation, scale, category, uncertainty, evidential status, or practical function that occurs when an object or result moves from one applied method into another.

Method-interface transformations should be documented when they affect later judgment. A rich narrative converted into a binary indicator, a probability distribution converted into a threshold, or a stakeholder preference converted into an optimization weight can each alter practical meaning. The transformation can be useful and legitimate, yet its consequences should remain reconstructable.

Combination also creates the possibility of triangulation. Agreement among methods can increase confidence when their errors and assumptions are sufficiently independent. Agreement among methods sharing the same data and model assumptions provides weaker confirmation. Disagreement can be equally informative. A divergence between statistical estimates, local knowledge, and historical reconstruction may reveal scale mismatch, category instability, distributional heterogeneity, or a changing mechanism. Method combination should therefore preserve meaningful disagreement long enough to diagnose its source.

Definition 11.17 (Methodological disagreement). *Methodological disagreement* is a materially relevant divergence among applied methods concerning description, mechanism, consequence, value, uncertainty, or practical implication that cannot be explained solely by superficial differences in presentation.

Methodological disagreement need not prevent action. It can alter the form of action. Deep disagreement about long-horizon consequences may support a reversible pilot rather than a full commitment. Divergence about affected positions may trigger additional participation. Conflicting causal accounts may justify monitoring designed to discriminate among mechanisms. Method combination thus connects directly to adaptive methodology.

The sequence of methods can itself shape the result. Beginning with a formal model can determine which variables later participants are asked to discuss. Beginning with participatory mapping can expand the categories entering later modelling. Historical reconstruction can shift the problem boundary before optimization begins. There is therefore no methodologically neutral ordering. Applied methodol-

ogy should select sequence according to the practical orientation and record where ordering can materially influence the object.

Proposition 11.18 (Differentiated methodological integration). *Method combination is most informative when methods retain their differentiated epistemic functions, interface transformations are documented, and agreement or disagreement is interpreted in relation to the independence, scope, and assumptions of the contributing methods.*

This proposition preserves methodological pluralism without romanticizing plurality. More methods do not automatically yield better practical judgment. Combination should be proportionate to consequence and organized around functions the practical situation actually requires. The final subsection addresses how the resulting methodological architecture remains revisable as the situation changes.

11.1.6 Revisability of Applied Methods

Applied methods operate in changing fields. Evidence accumulates, categories shift, technologies change, institutions learn, actors adapt, values are reconsidered, and interventions alter the conditions they were designed to address. A method that initially fits a practical object can therefore become poorly calibrated even when it continues to operate exactly as designed. Methodological revisability is the capacity to detect and govern this change.

Definition 11.19 (Method revisability). *Method revisability* is the organized capacity to modify, supplement, replace, suspend, or retire an applied method when changes in the practical orientation, evidence, situation, implementation trajectory, institutional capacity, or observed consequences materially alter its fit.

Revisability begins with revision triggers. A trigger can arise from persistent prediction error, new affected positions, failure of an assumption, changed data-generating processes, implementation drift, emerging harm, institutional reorganization, technological change, or conflict between method outputs and observed practical consequences. Some triggers can be specified in advance, while others emerge through monitoring and contestation.

Definition 11.20 (Method revision trigger). *A method revision trigger* is a predefined or emergent condition indicating that the current method's assumptions, function, representation, burden, or practical consequences require structured reassessment.

Method revision should distinguish parameter updating from architectural change. A forecast model can be updated with new data while preserving its structure. A decision criterion can change its threshold while preserving the underlying value architecture. More substantial revision may replace the model class, redefine the outcome, broaden participation, alter the intervention object, or change the method's practical function. Recording the depth of revision helps preserve comparability across time.

Definition 11.21 (Applied method version). *An applied method version* is a temporally identified specification of a method's purpose, assumptions, data or evidential base, procedures, parameters, authority, safeguards, and interfaces that permits later reconstruction of which methodological configuration governed a practical judgment or intervention at a given stage.

Versioning is especially important for automated and adaptive systems. A model

can change through retraining, data updates, prompt modification, software revision, or altered deployment rules while retaining the same public name. Without methodological versioning, later evaluation may attribute a consequence to a method whose actual operational configuration can no longer be reconstructed. The same issue appears in institutional routines whose informal practices evolve while formal documentation remains unchanged.

Revisability also has costs. Frequent methodological changes can weaken comparability, confuse responsibility, increase training burdens, and create instability. Institutions can become trapped between methodological inertia and methodological churn. A revisable architecture therefore requires continuity rules that identify which elements should remain stable long enough for learning and which can change rapidly in response to evidence.

Definition 11.22 (Method continuity rule). *A method continuity rule specifies which components of an applied methodological architecture should remain stable across a defined horizon, which components can be updated, who can authorize changes, and how comparability and responsibility will be preserved through revision.*

Methodological memory supports this balance. Institutions should retain records of prior method versions, reasons for change, failure signals, discarded alternatives, and consequences of revision. A method retired after poor performance can otherwise reappear later when organizational memory fades. Conversely, a useful method can be abandoned because the conditions under which it performed well are forgotten. Methodological memory turns revision history into an epistemic resource.

Revisability also includes recoupling with research. Some methodological problems exceed the capacity of embedded adaptation. Repeated model failure, unexplained heterogeneous effects, unstable categories, newly generated institutions, or persistent disagreement about mechanism can require a return toward research-dominant praxis. The applied method should preserve enough provenance, data lineage, practical context, and failure information for renewed inquiry to reconstruct the problem.

Definition 11.23 (Method recoupling condition). *A method recoupling condition is a practical or epistemic development indicating that modification within the existing applied methodological architecture is insufficient and that a defined question should return toward research-dominant inquiry for deeper reconstruction.*

The distinction between method revision and research recoupling prevents adaptive practice from absorbing every unresolved problem into local adjustment. Some anomalies deserve systematic inquiry because they challenge the categories, mechanisms, or assumptions on which practical action depends. Preserving this route sustains the continuity between Parts III and IV while allowing application-dominant praxis to remain action-oriented.

Proposition 11.24 (Revisable methodological continuity). *An applied methodological architecture can remain both stable enough for responsibility and learning and revisable enough for changing practical conditions when method versions, revision triggers, continuity rules, interface changes, and research-recoupling conditions are explicitly governed and historically preserved.*

Proposition 11.24 completes the transition from applied praxis to method. Practical

orientation specifies the direction and conditions of action. Decision objects identify bounded commitments. Intervention objects identify configurations toward which action is directed. Method selection connects methodological requirements to feasible procedures. Method combination coordinates partially irreducible forms of access and action. Revisability keeps the resulting architecture responsive to evidence, consequence, institutional change, and renewed inquiry.

The next methodological task is diagnosis. Before alternatives can be compared or interventions designed, the practical situation requires a structured reconstruction of actors, relations, constraints, capacities, histories, institutions, and uncertainty. Section 284 therefore develops practical diagnosis as the first major methodological family of Chapter 11.

11.2 Practical Diagnosis

Section 11.1 established the transition from practical orientation to organized method by distinguishing decision objects, intervention objects, method selection, method combination, and methodological revisability. The present section develops the first major methodological family required by that transition: practical diagnosis. Its role is to reconstruct the practical field before goals, criteria, epistemic-event and evidential architectures, alternatives, or interventions are specified in operational form. Its objective is to produce a disciplined and revisable account of the situation, actors, relations, constraints, capacities, historical formation, institutional configuration, and uncertainty that condition consequential action. The discussion proceeds through eight diagnostic movements: situation mapping, actor mapping, relation mapping, constraint mapping, capacity mapping, historical reconstruction, institutional diagnosis, and uncertainty mapping. The method is relational and reconstructive. It combines structured description with historical inquiry, positional comparison, institutional analysis, and explicit uncertainty recording while preserving the distinction between diagnosis, judgment, and intervention design.

Practical diagnosis performs a different function from problem formation in Chapter 10. Problem formation identifies a consequential configuration that has become practically salient and organizes it for judgment. Diagnosis asks how that configuration is constituted, reproduced, constrained, enabled, distributed, and historically formed. A problem can therefore be recognized before its diagnostic architecture is sufficiently developed. Conversely, diagnostic work can reveal that the original problem formulation is too narrow, uses unstable categories, omits affected positions, or mistakes a visible symptom for the relations that generate it. Diagnosis consequently remains coupled to problem revision while retaining a distinct methodological function.

A practical diagnosis also differs from a comprehensive description of everything surrounding a problem. Application-dominant praxis operates under limited time, attention, capability, and evidence. Diagnostic work therefore requires scope discipline. The relevant question is which features of the practical field materially affect understanding of the problem, the reachable action space, the distribution of consequences, or the capacity for learning and revision. A diagnostic architecture can

Table 11.2: Diagnostic architecture for application-dominant praxis

Diagnostic movement	Primary object	Characteristic question	Typical diagnostic risk
Situation mapping	Bounded practical field across positions, scales, and horizons	What configuration is being reconstructed for practical use?	Boundary compression, scale mismatch, and premature stabilization
Actor mapping	Persons, groups, organizations, collectives, and other practically relevant positions	Who can affect, experience, interpret, authorize, implement, maintain, or contest the practical trajectory?	Visibility bias, role conflation, and omission of weak or future positions
Relation mapping	Dependencies, exchanges, authority, information, care, conflict, coordination, and other consequential relations	Through which relations are effects generated, transmitted, amplified, or constrained?	Entity-centered description and unsupported causal attribution
Constraint mapping	Conditions that restrict, redirect, delay, price, or foreclose practical possibilities	Which conditions shape reachability and consequence across positions?	Treating constraints as fixed, uniform, or exclusively restrictive
Capacity mapping	Situated abilities to perceive, decide, coordinate, act, maintain, repair, learn, and revise	Which capacities exist, where are they located, and under what enabling conditions can they be mobilized?	Inferring capacity from resources, authority, or past output alone
Historical reconstruction	Sequences, inheritances, path dependencies, prior decisions, and accumulated consequences	How did the present practical configuration become reachable and persistent?	Presentism, retrospective inevitability, and excessive historical scope
Institutional diagnosis	Mandates, rules, roles, routines, interfaces, infrastructures, and organizational memory	How do durable arrangements enable, constrain, coordinate, and reproduce praxis?	Equating formal design with enacted institutional capacity
Uncertainty mapping	Epistemic, model, mechanism, implementation, value, and future-state uncertainty	What remains uncertain, why, for whom, and with what practical significance?	Single-score uncertainty and unrecorded ignorance

deepen when new evidence or implementation experience indicates that a previously backgrounded relation has become practically important.

Definition 11.25 (Practical diagnosis). A *practical diagnosis* is a structured and revisable reconstruction of the actors, relations, conditions, constraints, capacities, histories, institutions, and uncertainties that materially shape a practical problem, its reachable responses, and the consequences of action or inaction.

Definition 11.25 treats diagnosis as an applied methodological object rather than a one-time descriptive report. A diagnosis should identify its scope, standpoint, evidence base, temporal horizon, scale, unresolved uncertainty, and conditions for revision. It should also distinguish observed conditions from interpretive reconstruction and stronger generative claims. The same practical field can support several diagnostic representations when different questions, scales, or affected positions are relevant. Methodological discipline requires these differences to remain inspectable rather than being compressed into a single apparently neutral map.

Table 11.2 summarizes the eight diagnostic movements developed in this section. The table is a functional architecture rather than a mandatory sequence. Some practical situations require historical reconstruction before actor mapping; others begin with institutional boundaries or uncertainty. The diagnostic movements can therefore be iterated and reordered while their analytical functions remain distinguishable.

The architecture in Table 11.2 is deliberately relational. Situation mapping provides the diagnostic boundary; actor and relation mapping identify positions and connections; constraint and capacity mapping reconstruct the structure of practical possibility; historical and institutional analysis explain how that structure has formed and is reproduced; uncertainty mapping records the limits of the reconstruction. These components jointly produce a diagnosis that can support the subsequent specification of goals and criteria in Section 285 while remaining open to revision.

11.2.1 Situation Mapping

Situation mapping specifies the field to which the diagnosis refers. Chapter 10 defined a practical situation as a stage-, scale-, and standpoint-indexed relational configuration. The methodological task here is to make those indices explicit enough for later analysis. A situation map should identify the practical object, spatial or organizational boundary, temporal horizon, relevant scales, focal positions, material conditions, institutional interfaces, and major sources of change that define the current reconstruction.

Definition 11.26 (Situation map). A *situation map* is a bounded and revisable representation of the practical field that records the focal problem, relevant positions, material and institutional conditions, scales, temporal horizons, major relations, and diagnostic boundary conditions used for applied analysis.

The boundary of a situation map is an analytical and practical choice. It can follow a neighborhood, organization, legal jurisdiction, infrastructure network, supply chain, ecological region, project boundary, or another relationally relevant unit. The boundary should be justified by the problem and mechanisms under investigation rather than by convenience alone. A formally available administrative boundary can be useful for authority and data while failing to contain the relations that generate the practical problem. Conversely, a very broad relational boundary can create analytical overload and weaken operational relevance. Situation mapping therefore requires a proportionate boundary that remains revisable when omitted relations become consequential.

A diagnostic boundary can be represented through a *core field* and one or more *interface fields*. The core field contains relations and conditions currently treated as central to the practical problem. Interface fields contain adjacent systems, institutions, populations, or environments through which important inputs, spillovers, constraints, or consequences may enter. This distinction allows diagnosis to retain focus while preserving pathways for boundary expansion.

Definition 11.27 (Diagnostic boundary profile). A *diagnostic boundary profile* records the core field, relevant interface fields, excluded domains, reasons for inclusion or exclusion, expected spillover pathways, and conditions that would require boundary revision.

Situation maps also require scale discipline. A pattern visible at one scale can obscure heterogeneity at another. Aggregate service availability can coexist with neighborhood exclusion. Organizational compliance can coexist with local implementation failure. A stable national indicator can coexist with rapidly changing subgroup exposure. Diagnostic work should therefore state which scale each claim refers to

and identify where cross-scale interactions are expected to matter.

Temporal boundaries require similar care. An immediate practical crisis can demand a short diagnostic horizon for stabilization while its generative conditions extend across years or decades. A long historical horizon can illuminate institutional formation while providing little guidance about an acute operational bottleneck. Situation mapping can therefore use several nested horizons: an immediate decision horizon, an implementation horizon, a structural horizon, and a historical horizon. Their relation should remain explicit because the significance of actors, constraints, capacities, and risks can change across time.

Standpoint is another constitutive dimension. Decision-makers, implementers, affected subjects, maintainers, and actors with exit capacity may inhabit different versions of the same practical field. A situation map can record these positional differences rather than choosing one as the uniquely authoritative view. Positional comparison can reveal that an arrangement experienced as efficient by one actor is experienced as inaccessible, risky, or burdensome by another. Such divergence is diagnostically important even before a normative judgment is made.

Situation mapping should also identify change processes already underway. A practical field is rarely static at the moment of diagnosis. Migration, technological adoption, institutional reform, ecological change, political turnover, market adjustment, infrastructure degradation, learning, conflict, or informal adaptation may be altering the conditions under which later methods will operate. A map that captures only a snapshot can therefore become obsolete before intervention begins. Recording directional change and known transition processes increases the usefulness of the diagnosis for later scenario and adaptive methods.

Proposition 11.28 (Revisable situational boundary). *A practical situation is most usefully mapped when its diagnostic boundary is explicit, proportionate to the practical object, sensitive to relevant scales and standpoints, and accompanied by conditions under which the boundary should be expanded, contracted, or re-indexed.*

Proposition 11.28 makes situation mapping a methodological commitment rather than a neutral prelude. Later actor, relation, constraint, and capacity maps inherit the boundary choices established here. Recording those choices supports revision when the diagnosis encounters evidence that its original field was too narrow or too broad.

11.2.2 Actor Mapping

Actor mapping identifies the positions whose agency, exposure, knowledge, authority, dependence, contribution, or contestation materially affect the practical trajectory. The term *actor* is used functionally in this subsection. It can include individuals, households, professional groups, organizations, agencies, communities, firms, networks, coalitions, technical systems with delegated operational roles, or other positions through which consequential action is organized. The map should preserve distinctions among actors rather than assuming a single unitary form of agency.

Definition 11.29 (Practical actor map). *A practical actor map is a structured representation of the positions that can materially affect, experience, interpret, authorize,*

implement, maintain, resist, contest, or revise a practical trajectory, together with their relevant roles, resources, capacities, dependencies, and exposure.

Actor mapping begins with role differentiation. Chapter 10 distinguished affected subjects, stakeholders, participants, representatives, and decision-holders. Practical diagnosis adds implementers, maintainers, monitors, evaluators, intermediaries, infrastructure providers, knowledge holders, gatekeepers, beneficiaries, risk bearers, and actors whose cooperation or refusal materially changes the action space. A single person or institution can occupy several roles, and the same role can be distributed across several actors. The diagnostic task is therefore to map role configuration rather than merely list organizational names.

Visibility creates a recurring bias. Actors with formal authority, abundant data, technical expertise, or organizational resources are easier to identify. Actors who experience diffuse burdens, possess local knowledge, lack recognized representation, operate informally, or enter only at later stages can remain absent. Future maintainers and future affected positions are especially easy to omit because they are not present during initial diagnosis. Actor mapping should therefore include an explicit search for low-visibility positions whose practical relevance exceeds their current institutional visibility.

Definition 11.30 (Actor visibility gap). An *actor visibility gap* is a diagnostically relevant difference between an actor's practical significance and the degree to which that actor is represented in the available data, institutional process, formal authority structure, or current problem formulation.

A practical actor map should also record positional attributes without turning them into fixed identities. Relevant attributes can include decision authority, implementation responsibility, access to information, exposure to risk, capacity to wait, ability to exit, dependence on infrastructure, technical expertise, social trust, legal standing, or access to remedial pathways. Their relevance depends on the practical object. Mapping should therefore remain selective and purpose-linked.

Actor maps benefit from distinguishing direct, indirect, and conditional relevance. Direct actors participate in or experience the focal practical process. Indirect actors shape enabling conditions, supply resources, establish rules, or absorb spillovers. Conditional actors become relevant when particular scenarios, thresholds, failures, or escalation pathways occur. This distinction is useful for emergency arrangements in which dormant authority or backup capability becomes important only under defined conditions.

Actors can also change through the practical process. An affected group can organize and become a collective decision participant. A technical vendor can gain infrastructural power as dependence deepens. A local intermediary can become a central knowledge broker. A regulator can shift from oversight to direct intervention after threshold breach. Actor mapping should therefore record plausible role transitions rather than treating the field as institutionally frozen.

Agency should be distinguished from formal authority. A formally subordinate actor can possess substantial practical agency through expertise, network centrality, refusal capacity, local legitimacy, or control over indispensable infrastructure. An actor with formal authority can possess weak effective agency because of resource

scarcity, fragmented jurisdiction, low trust, or implementation dependence. Actor mapping should therefore be linked to relation, constraint, and capacity maps before conclusions about practical power are drawn.

Definition 11.31 (Actor-role profile). An *actor-role profile* records an actor's relevant practical roles, authority, exposure, knowledge position, dependencies, capacities, participation pathways, exit conditions, and plausible role transitions within a specified diagnostic field.

Actor mapping also supports later participation design. The presence of an actor on a diagnostic map does not by itself determine that actor's decision right or participatory status. It establishes practical relevance that can inform later judgments about representation, consultation, authority, accountability, and contestability. Keeping diagnosis separate from allocation of decision rights prevents the actor map from becoming an implicit governance decision.

The map should preserve uncertainty about actor boundaries where collective identity is unsettled. Communities, networks, organizations, and coalitions often contain internal disagreement. Treating them as homogeneous can erase minority positions or hidden role differences. Actor mapping can therefore use nested representation: the collective can appear as a practical actor while internal subpositions remain visible when they materially affect diagnosis.

Proposition 11.32 (Role-sensitive actor diagnosis). *Actor mapping is diagnostically stronger when practical relevance, role configuration, visibility, effective agency, and internal heterogeneity are recorded separately from formal status or nominal membership.*

This proposition prepares relation mapping. Actors become practically intelligible through the relations that connect them. The next diagnostic movement therefore shifts attention from positions to the structures through which authority, information, resources, dependence, care, conflict, and consequences travel.

11.2.3 Relation Mapping

Relation mapping reconstructs the connections through which the practical field is generated and maintained. An entity list can identify who is present while leaving unexplained how effects propagate, why some actors depend on others, where coordination fails, or how institutional power is converted into practical consequence. Relation mapping therefore treats dependencies, exchanges, authority, information, care, trust, conflict, coordination, representation, maintenance, and material flows as diagnostic objects in their own right.

Definition 11.33 (Practical relation map). A *practical relation map* is a structured representation of consequential relations among practical positions, including the direction, content, strength, conditions, asymmetry, temporal pattern, and uncertainty of those relations where these properties are relevant to the diagnosis.

A relation map should specify what is related. A connection can concern authority, information, finance, material resources, technical dependency, care, obligation, recognition, trust, representation, conflict, data, maintenance, legal responsibility, or another practical object. Using a single undifferentiated edge between actors can

hide major differences in mechanism. A relationship of information dependence can coexist with legal autonomy; a relationship of financial support can coexist with weak operational influence; a relationship of formal supervision can coexist with strong implementation dependence in the reverse direction.

Direction also matters. Some relations are reciprocal, while others are strongly asymmetric. Information can flow from local implementers to a central authority while decisions flow in the opposite direction. Maintenance obligations can flow toward one actor while benefits are distributed elsewhere. Risk can be imposed downstream while authority remains upstream. Recording direction helps diagnose where responsibilities, consequences, and capabilities become separated.

Relation mapping should also identify interfaces. Practical failure frequently occurs at interfaces between otherwise competent units. Information can be lost between agencies, standards can be incompatible across technical systems, responsibility can fall between organizational mandates, or an intervention can require cooperation from an actor whose incentives were never considered. An interface is therefore more than a boundary; it is a place where translation, transfer, coordination, or joint action must occur.

Definition 11.34 (Practical interface). A *practical interface* is a relational site at which information, authority, resources, responsibility, interpretation, technical outputs, or coordinated action must pass between positions, systems, or institutional domains for a practical process to function.

Interfaces can be robust, fragile, redundant, contested, or absent. Their quality can matter more than the average capacity of the participating actors. A high-capacity institution can fail when its outputs cannot be used by downstream actors. A technically sound monitoring system can remain practically inert if there is no interface linking warning signals to authorized response. Interface diagnosis should therefore record translation rules, latency, redundancy, escalation pathways, and failure modes where these features are consequential.

Relational asymmetry requires careful interpretation. Unequal authority, information, resources, or exit capacity can generate practical power when conversion conditions permit. Relation mapping can identify such asymmetries while leaving normative evaluation to later sections. It can also reveal countervailing relations: formal hierarchy can be moderated by professional norms, legal review, reputational dependence, or technical reliance on subordinate actors. The map should represent effective relational structure rather than assume that one formal hierarchy explains the whole field.

Relations can be multiplex. The same two actors can cooperate in one domain, compete in another, exchange information, share infrastructure, and hold mutual legal obligations. Multiplex relations can create resilience through redundancy or fragility through coupled dependence. Diagnostic representations should therefore preserve relation type when collapsing several relations would obscure practical mechanism.

Temporal pattern is similarly important. Some relations are continuous; others activate during crisis, contract renewal, maintenance cycles, elections, budget periods, seasonal change, or threshold events. A dormant emergency coordination relation can become decisive during failure. Relation mapping can record activation condi-

tions so later scenario and adaptive methods know which connections are expected to become operative under changing conditions.

A relation map should also distinguish observation from generative interpretation. Repeated co-occurrence or communication does not by itself establish a mechanism. Diagnostic work can propose a relational hypothesis while recording the evidence and alternatives that support it. This is especially important when relation maps are generated from digital traces, network data, organizational charts, or interview accounts whose representational limits differ.

Definition 11.35 (Relational diagnostic claim). *A relational diagnostic claim is an evidentially bounded proposition concerning how a specified relation contributes to the reproduction, transmission, amplification, inhibition, or transformation of a practical condition.*

Relational diagnostic claims can be weak or strong. A weak claim may identify a repeated dependency or communication pathway. A stronger claim may propose that the relation generates a bottleneck, reinforces an institutional pattern, or transmits risk. Stronger claims require correspondingly stronger evidence and should remain revisable when implementation produces new traces.

Proposition 11.36 (Relational diagnostic priority). *When practical consequences depend materially on coordination, dependence, transmission, authority, or interface conditions, diagnosis should represent those relations explicitly rather than infer the practical field from actor attributes alone.*

Relation mapping provides the basis for the next two diagnostic movements. Constraints and capacities are frequently relational properties: a condition can constrain one actor while enabling another, and a capacity can depend on access to other actors, institutions, infrastructure, or trust. Their maps should therefore remain linked to the relational architecture developed here.

11.2.4 Constraint Mapping

Constraint mapping identifies the conditions that restrict, redirect, delay, increase the cost of, or foreclose practical possibilities. Chapter 10 treated constraints as constitutive elements of the action space. The methodological task is to locate them, identify the positions and pathways through which they operate, and distinguish their current effects from assumptions about their permanence.

Definition 11.37 (Practical constraint map). *A practical constraint map is a structured representation of conditions that materially limit, redirect, delay, price, condition, or foreclose practical actions, together with their affected positions, activation conditions, temporal persistence, relational pathways, and degree of modifiability where these can be established.*

Constraints can be material, institutional, legal, informational, technological, organizational, financial, temporal, ecological, cultural, relational, or capability-based. The categories are analytical aids rather than mutually exclusive types. A legal requirement can become a temporal constraint through lengthy procedure; a technical standard can become an institutional constraint when procurement depends on it; a social norm can become a coordination constraint when actors expect sanction for

deviation. Constraint mapping should therefore record how a constraint operates rather than assign it only to a category.

A useful distinction concerns hard, soft, and contingent constraints. A hard constraint is treated as effectively fixed within the relevant practical horizon, such as a physical limit or binding legal prohibition that cannot realistically be altered before the decision. A soft constraint can be changed through feasible resource, coordination, institutional, or design adjustments. A contingent constraint applies only under specified conditions, scenarios, or actor configurations. This classification should remain horizon-sensitive: a constraint hard in an emergency horizon can become soft over institutional reform time.

Definition 11.38 (Constraint modifiability profile). A *constraint modifiability profile* records the practical horizon, actors, resources, authority, dependencies, and conditions under which a diagnosed constraint can plausibly remain fixed, be relaxed, be bypassed, be transformed, or be removed.

This profile prevents a common diagnostic error in which historically produced constraints are treated as natural facts. Institutional rules, organizational routines, infrastructure arrangements, category systems, and resource distributions can acquire the appearance of necessity because they have persisted. Historical reconstruction can reveal that their current form is contingent and potentially transformable, even when rapid change remains impractical.

Constraints are also positional. A requirement can impose little burden on a large organization while effectively excluding a small group. A digital procedure can reduce administrative cost for one institution while increasing access barriers for users with limited connectivity. A standardized schedule can improve coordination while constraining actors with care responsibilities. Constraint maps should therefore record distribution rather than assume uniform effect.

Constraints can interact. Several individually manageable conditions can combine into a binding configuration. Limited authority, fragmented information, and short decision time can jointly make a response unreachable even when each element alone appears moderate. Diagnostic work should therefore search for constraint bundles and threshold effects rather than only rank isolated barriers.

Definition 11.39 (Constraint configuration). A *constraint configuration* is a set of interacting constraints whose combined effect on practical reachability or consequence differs materially from the effect expected from considering each constraint separately.

The same condition can also function as an enabling constraint. Rights protections, safety standards, ecological limits, audit requirements, and procedural safeguards can restrict immediate action while preserving legitimacy, reliability, or future options. Constraint mapping should therefore describe function before normative evaluation. Later goal and criterion specification can determine whether the constraint should be preserved, modified, or treated as a design requirement.

Constraint maps should also identify who bears the cost of compliance and who has the capacity to modify the constraint. This information links diagnosis to power and justice without resolving those normative questions inside the diagnostic stage. A rule that appears equally binding can generate unequal effective action spaces when

actors differ in resources, time, expertise, or access to exception procedures.

The relation between constraints and intervention objects is especially important. Some practical projects target a visible outcome while leaving the constraints that reproduce it unchanged. Others attempt to remove a constraint while overlooking the functions it currently performs. Diagnosis should therefore distinguish symptom-level restrictions from generative constraints and record plausible consequences of altering them. A constraint map can identify candidate intervention objects while leaving target selection to Section 297.

Proposition 11.40 (Constraint diagnosis and reachability). *A diagnosed constraint becomes practically informative when its affected positions, operating pathway, temporal horizon, interactions, and modifiability are sufficiently specified to explain how it changes the reachability or consequence of relevant actions.*

Constraint mapping naturally pairs with capacity mapping. Practical possibility is shaped jointly by what restricts action and what enables actors or institutions to perceive, coordinate, act, sustain, repair, and revise. The next subsection therefore reconstructs the enabling side of the action space.

11.2.5 Capacity Mapping

Capacity mapping identifies the situated abilities through which actors and institutions can perform practical functions. Capacity is neither a stock of resources nor a record of past output. A capacity exists through enabling configurations that can include knowledge, authority, relationships, infrastructure, routines, time, trust, material resources, and access to complementary capabilities. The diagnostic task is to identify which capacities matter, where they are located, how they can be mobilized, and how durable they are under practical demand.

Definition 11.41 (Practical capacity map). *A practical capacity map is a structured representation of the situated abilities required to perceive, interpret, decide, coordinate, act, maintain, monitor, repair, learn, and revise within a practical field, together with their carriers, enabling conditions, dependencies, activation costs, limits, and signs of depletion or development.*

Capacity mapping should begin from function. A project can require diagnostic capacity, decision capacity, implementation capacity, coordination capacity, maintenance capacity, monitoring capacity, repair capacity, participatory capacity, or learning capacity. Treating these as one general organizational capability can hide important gaps. An institution can make high-quality decisions while lacking implementation reach; it can implement rapidly while lacking monitoring and repair; it can collect data while lacking interpretive capacity to use them.

Resources contribute to capacity when conversion conditions are present. Funding without procurement capability may remain unusable. Expertise without authority can remain advisory. Legal authority without staff, information, or trust can remain nominal. Infrastructure without maintenance can deteriorate. Capacity mapping should therefore identify conversion pathways linking resources and institutional positions to effective practical ability.

Definition 11.42 (Capacity activation pathway). *A capacity activation pathway is the*

set of enabling relations, resources, permissions, competencies, infrastructures, and coordination conditions through which a latent or nominal capability becomes practically deployable for a specified function.

Activation pathways can reveal bottlenecks that are invisible in resource inventories. A trained team may require data access controlled elsewhere. A local organization may possess contextual knowledge but lack a recognized interface with decision-makers. A technical system may have analytical capability while lacking a legal basis for operational use. Diagnosis should therefore connect capacity maps with actor and relation maps.

Capacity is also distributed. Collective capacity can arise from complementary positions whose individual abilities are insufficient alone. Emergency response can depend on coordination among sensing, communication, transport, medical, and authorization functions. Institutional learning can depend on front-line observation, archival memory, analytical expertise, and management authority. Capacity mapping should represent the configuration through which these functions combine rather than sum individual attributes.

Definition 11.43 (Collective capacity configuration). A *collective capacity configuration* is an organized set of complementary abilities, relations, interfaces, and enabling conditions whose coordination permits a practical function that the participating positions could not reliably perform in isolation.

Latent capacity is diagnostically important. Actors can possess abilities that are currently inactive because coordination, authority, trust, resources, or recognition are absent. A crisis can activate dormant networks; a new interface can make local expertise usable; a policy change can unlock previously unavailable institutional capacity. Diagnosis can record plausible latent capacities where there is evidential support for the activation pathway. Speculative possibility should remain distinguished from practically supportable latent capacity.

Capacity can also be depleted. Intensive implementation can consume staff attention, trust, financial reserves, maintenance slack, political legitimacy, or informal cooperation while short-run output remains high. A capacity map should therefore include sustainability and recovery where the practical horizon extends beyond immediate delivery. High current performance can coexist with declining future capacity.

Definition 11.44 (Capacity sustainability profile). A *capacity sustainability profile* records the resources, relationships, maintenance, renewal, workload, learning, and recovery conditions required for a practical capacity to persist across the relevant horizon.

This profile is especially important for interventions that rely on extraordinary effort. A pilot can succeed because a small team supplies exceptional attention that cannot be maintained at scale. An emergency arrangement can function temporarily while accumulating deferred maintenance. Diagnostic work should therefore distinguish demonstrated capacity under current conditions from scalable and sustainable capacity.

Capacity maps can also identify asymmetry. Actors can differ in capacity to wait, absorb loss, interpret technical information, organize collectively, navigate institu-

tions, or exit. These differences shape the effective action space and later participation. Diagnosis records the asymmetry without yet deciding what justice requires.

Finally, capacity is endogenous to praxis. Interventions can build, erode, redistribute, or lock in capabilities. A practical diagnosis therefore provides a baseline for later evaluation of capacity change. It can also reveal that capacity generation itself may become an intervention object. Section 297 will address target selection more directly; the present task is to make the existing capacity architecture visible.

Proposition 11.45 (Capacity conversion discipline). *Capacity should be attributed to a practical position when a specified function, enabling configuration, and plausible activation pathway can be identified, with relevant dependencies, limits, and sustainability conditions recorded where they materially affect practical use.*

The relation between present capacity and earlier formation leads to historical reconstruction. Capacities, constraints, relations, and institutional arrangements are products of prior trajectories whose reconstruction can explain why the current field possesses its present structure.

11.2.6 Historical Reconstruction

Historical reconstruction identifies the sequences through which the present practical field became reachable, persistent, and interpretable. Its function is diagnostic rather than antiquarian. The objective is to explain current relations, constraints, capacities, institutions, and expectations where their practical significance depends on inherited decisions, path dependencies, accumulated consequences, prior crises, classification systems, or institutional learning.

Definition 11.46 (Practical historical reconstruction). *A practical historical reconstruction is a problem-oriented account of the sequences, decisions, contingencies, institutional changes, accumulated effects, and inherited interpretations through which a present practical configuration acquired materially relevant features.*

The appropriate historical depth depends on the object. An equipment failure can require reconstruction of maintenance history, procurement, and recent operating conditions. A persistent institutional disparity can require examination of earlier rules, exclusions, infrastructures, and value classifications. A coordination failure can arise from an organizational merger whose incompatible procedures remain embedded years later. Historical reconstruction should therefore select depth according to the generative pathways that remain active in the present.

A useful diagnostic distinction separates historical antecedence from historical carryover. Many past events precede the present condition, while only some continue to shape it through identifiable pathways. A practical historical account should therefore trace the relation through which an earlier decision or condition persists: infrastructure, legal rule, institutional memory, debt, expectation, skill distribution, category, ownership structure, trust, stigma, or another durable carrier.

Definition 11.47 (Historical carryover pathway). *A historical carryover pathway is a reconstructable relation through which an earlier event, decision, institution, classification, investment, conflict, or consequence continues to shape a present practical condition.*

This definition guards against two opposing errors. Presentism treats the current field as if it were produced only by contemporary choices. Retrospective overreach attributes current outcomes to distant history without identifying a continuing mechanism. Historical diagnosis should connect past and present through evidence of persistence, transformation, or inherited constraint.

Historical reconstruction should also preserve contingency. Current arrangements can appear inevitable once they have stabilized. Yet earlier actors often faced several reachable alternatives, incomplete knowledge, and competing values. Reconstructing those alternatives can reveal path dependence, lock-in, and lost capacities while resisting retrospective certainty. It can also identify moments when intervention changed the set of later possibilities.

Institutional memory provides one source for this reconstruction, but official records can be selective. Archives, policy documents, technical logs, budgets, correspondence, prior evaluations, oral testimony, local memory, and material traces can provide complementary access. Their evidential statuses differ. A practical historical reconstruction should record where the account rests on official records, experiential testimony, inference, or later reinterpretation.

Historical categories require caution. Terms used in earlier periods can differ from current analytical categories. Reclassifying the past through current concepts can make comparison possible while introducing distortion. Diagnostic history should therefore distinguish actor categories used at the time from present analytical categories where the difference matters. This supports the broader book principle that concepts themselves have histories.

Historical reconstruction can also reveal repeated intervention patterns. Institutions may repeatedly respond to symptoms while leaving generative constraints intact. A policy cycle may alternate between centralization and decentralization. Maintenance may be deferred until crisis. Participation may expand during reform and contract during implementation. Identifying such recurrent structures can inform later scenario construction and robustness analysis without assuming that history repeats mechanically.

Definition 11.48 (Practical path record). A *practical path record* is a structured account of materially relevant turning points, contingencies, commitments, carryover pathways, lost alternatives, accumulated consequences, and prior adaptations that help explain the present practical configuration.

Historical reconstruction also changes responsibility analysis. Present actors can inherit conditions they did not create while possessing varying capacities to maintain, repair, or transform them. Diagnosis should therefore separate origin, inheritance, current control, and current response capacity. Later sections can use this distinction when specifying goals, criteria, responsibility, and justice.

Proposition 11.49 (Historical diagnostic relevance). *Historical material is diagnostically relevant when it clarifies a continuing relation, inherited condition, path dependence, institutional memory, capacity, constraint, or expectation that materially affects the current practical field or its reachable transformations.*

The historical record often converges on institutions as durable carriers of earlier decisions and present capacities. The next subsection therefore reconstructs the en-

acted institutional configuration through which practical action is authorized, coordinated, remembered, constrained, and revised.

11.2.7 Institutional Diagnosis

Institutional diagnosis examines the durable arrangements through which praxis is organized. Chapter 10 developed mandates, capacity, constraints, memory, collective decision, coordination, cooperation, conflict, trust, and collective generativity as dimensions of institutional praxis. The methodological task here is to reconstruct how those dimensions operate in the present practical field, with particular attention to divergence between formal design and enacted practice.

Definition 11.50 (Institutional diagnosis). An *institutional diagnosis* is a structured and revisable reconstruction of the mandates, roles, rules, routines, infrastructures, decision rights, interfaces, capacities, constraints, memory, accountability pathways, and informal practices through which a practical field is organized and reproduced.

Institutional diagnosis begins with mandate and authority. Formal mandates define recognized responsibilities and permissions, while actual practice can distribute influence differently. Overlapping mandates can create conflict or redundancy; mandate gaps can leave important practical objects without a responsible institution; broad mandates can exceed available capacity; narrow mandates can prevent actors from addressing cross-boundary problems. Diagnosis should therefore map the relation between formal mandate, practical authority, and operational reach.

Rules also require an enacted perspective. Written procedure can differ from routine implementation because of workload, informal adaptation, local interpretation, technological systems, professional norms, or resource constraints. Institutional diagnosis should identify where formal rules are decisive, where discretion operates, and where workarounds have become stable parts of the system. Such workarounds can increase resilience while also hiding structural mismatch.

Definition 11.51 (Enacted institutional configuration). An *enacted institutional configuration* is the practically operative arrangement of formal rules, informal routines, infrastructures, role expectations, discretionary practices, resource flows, and relational dependencies through which institutional action is actually produced.

Decision architecture is another diagnostic object. The relevant questions include who can place issues on the agenda, who supplies evidence, who interprets it, who can authorize commitment, who implements, who can suspend action, who monitors, who evaluates, and who can reopen the decision. Mapping only the final decision-maker can obscure substantial upstream and downstream power.

Interfaces deserve special attention. Institutional fields frequently depend on handoffs across agencies, departments, professional groups, jurisdictions, contractors, or technical systems. A mandate can be clear within each unit while responsibility for the interface remains ambiguous. Institutional diagnosis should therefore search for interface gaps, duplicate authority, translation burdens, incompatible data standards, escalation failures, and unclear maintenance responsibility.

Institutional capacity should be reconstructed through enacted function rather than formal resource inventories alone. Staff, budgets, legal authority, technology,

procedures, and expertise become capacity when they can be coordinated toward practical tasks. Diagnosis can compare mandate requirements with demonstrated and latent capacities, identifying where the institution is overextended or where unrecognized capability exists.

Institutional memory is similarly practical. Archives, databases, manuals, professional experience, long-standing relationships, and routines can preserve knowledge across time. Memory becomes fragile when personnel turnover, outsourcing, incompatible information systems, organizational restructuring, or undocumented workarounds break continuity. Institutional diagnosis should identify what knowledge is retained, where it resides, how it can be retrieved, and whether it remains connected to decision and revision pathways.

Accountability architecture should also be mapped diagnostically. Reporting obligations, audit, legal review, professional discipline, public scrutiny, grievance systems, appeals, internal review, and informal norms can create different forms of answerability. Their presence does not guarantee effective accountability. Diagnosis should record whether a pathway can receive a concern, investigate it, require response, authorize correction, and preserve a record. A nominal complaint mechanism with no practical remedy performs a different function from a contestability pathway linked to decision revision.

Trust and legitimacy can affect institutional capacity. Low trust can reduce reporting, cooperation, compliance, or participation even when formal authority is strong. High trust can facilitate coordination while also weakening scrutiny if expectations become insufficiently calibrated. Institutional diagnosis can record trust relations where they materially affect the operation of procedures or the willingness of actors to rely on institutional commitments.

Institutional diagnosis should also identify self-revision capacity. Some institutions can detect failure, preserve dissent, compare outcomes, modify procedures, and redistribute authority. Others reproduce established arrangements despite changing conditions. This capacity matters for adaptive methodology because later monitoring and evaluation are useful only when institutions possess a pathway through which learning can alter action.

Definition 11.52 (Institutional revision capacity). *Institutional revision capacity* is the enacted ability of an institutional configuration to detect materially relevant mismatch, preserve and interpret evidence, contest existing arrangements, authorize change, implement revision, and maintain sufficient continuity for responsibility and learning.

Institutional diagnosis can therefore reveal both intervention opportunities and intervention limits. A technically appropriate design can fail if it assumes authority, coordination, maintenance, or learning capacity that the institution does not possess. Conversely, institutional strengths can support interventions that would appear infeasible from a resource-only perspective.

Proposition 11.53 (Formal–enacted institutional distinction). *Institutional diagnosis should distinguish formal mandates, rules, and structures from enacted roles, routines, interfaces, capacities, and accountability pathways whenever divergence between them can materially alter practical consequence.*

The institutional reconstruction remains incomplete without an explicit account of uncertainty. Every map developed in this section is based on partial evidence, interpretive choices, changing conditions, and unresolved mechanisms. The final subsection therefore makes uncertainty part of the diagnosis itself.

11.2.8 Uncertainty Mapping

Uncertainty mapping records the limits of the practical diagnosis and the practical significance of those limits. The objective is broader than attaching confidence intervals to quantitative estimates. Practical uncertainty can concern missing actors, unstable categories, disputed relations, unknown mechanisms, future institutional behavior, implementation variability, value disagreement, data quality, model structure, or possible states that have not yet been imagined. These forms of uncertainty influence method selection, decision thresholds, participation, monitoring, and the reversibility of later commitments.

Definition 11.54 (Diagnostic uncertainty map). A *diagnostic uncertainty map* is a structured representation of materially relevant unknowns, ambiguities, contested interpretations, model limitations, evidential gaps, and future contingencies, together with their location in the diagnosis, practical significance, affected positions, and possible pathways for learning or protection.

A useful uncertainty map distinguishes several forms. *Observational uncertainty* concerns measurement, missing data, sampling, reporting, or access. *Representational uncertainty* concerns categories, boundaries, proxies, and model structure. *Mechanism uncertainty* concerns how observed relations generate outcomes. *Implementation uncertainty* concerns how action will be enacted across contexts and actors. *Behavioral or strategic uncertainty* concerns adaptation, resistance, cooperation, or gaming. *Future-state uncertainty* concerns external changes in technology, institutions, environment, or demand. *Normative uncertainty* concerns unresolved values, thresholds, standing, or priority rules. These forms can overlap while supporting different methodological responses.

Definition 11.55 (Uncertainty location). An *uncertainty location* is the diagnostic component—actor, relation, constraint, capacity, history, institution, category, mechanism, value, or future condition—within which a materially relevant uncertainty enters the practical analysis.

Locating uncertainty prevents a single global confidence statement from obscuring where the diagnosis is fragile. High confidence in actor identification can coexist with low confidence in causal mechanism. A well-measured current state can coexist with deep uncertainty about future adaptation. A technically precise model can coexist with contested normative thresholds. Different uncertainty locations can therefore imply different responses.

Uncertainty should also be ranked by practical relevance rather than epistemic curiosity alone. Some unknowns have little effect on the set of acceptable actions; others determine whether an intervention could create serious harm. A diagnostic process can use *decision relevance* to prioritize further inquiry. This does not require the decision itself to be fixed in advance. It requires a provisional understanding of which uncertainties could materially alter practical judgment, action-space reacha-

bility, risk distribution, or reversibility.

Definition 11.56 (Decision-relevant diagnostic uncertainty). A *decision-relevant diagnostic uncertainty* is an uncertainty whose plausible resolution could materially change the formulation of the practical problem, the set or ranking of reachable actions, the distribution of consequences, the required safeguards, or the conditions for provisional closure.

Uncertainty mapping should identify learning pathways where available. Additional measurement can reduce observational uncertainty. Comparative analysis can test category stability. Historical reconstruction can clarify path dependence. Participation can reveal omitted actors or values. Pilots can generate implementation evidence. Monitoring can track evolving conditions. Formal sensitivity analysis can test parameter dependence. Some uncertainty, however, cannot be reduced within the relevant horizon. It may require robust action, option preservation, staged commitment, protective thresholds, or explicit residual uncertainty carriage.

Ignorance deserves a place in the diagnostic architecture. Known unknowns can be recorded directly, while unknown unknowns are harder to represent. Practical diagnosis can nevertheless create conditions for discovering them: preserving dissent, maintaining open reporting channels, including heterogeneous standpoints, monitoring unexpected outcomes, and avoiding overly rigid categories. An uncertainty map can therefore record *ignorance-sensitive interfaces* where novel information is most likely to emerge.

Definition 11.57 (Ignorance-sensitive interface). An *ignorance-sensitive interface* is a monitoring, participatory, institutional, or observational pathway designed to increase the probability that materially relevant unanticipated conditions or consequences can become visible to the practical process.

Uncertainty is also distributed. Decision-makers can be uncertain about local experience while affected subjects possess strong situated knowledge. Front-line actors can recognize implementation fragility that central institutions underestimate. Technical experts can understand model uncertainty that political authorities or the public do not see. A diagnostic uncertainty map should therefore record whose uncertainty and whose knowledge are being represented. Apparent uncertainty can sometimes be a problem of disconnected knowledge rather than absence of knowledge.

The map should preserve disagreement where interpretations differ. Two diagnostic teams can agree on observations while disagreeing about mechanism. Actors can agree on mechanism while disagreeing about future behavior or normative significance. Recording the location and basis of disagreement helps later method combination and participatory decision design. Forcing premature consensus can hide uncertainty that matters for robust or adaptive action.

Diagnostic uncertainty also changes through time. Evidence can reduce one uncertainty while intervention generates another. A pilot can clarify implementation while revealing new relational dependencies. Institutional reform can reduce mandate ambiguity while creating transition risk. Uncertainty mapping should therefore be versioned alongside the diagnosis.

Definition 11.58 (Diagnostic revision record). A *diagnostic revision record* doc-

uments materially relevant changes in the situation, actor, relation, constraint, capacity, historical, institutional, or uncertainty maps, together with the evidence, practical event, or interpretive reason that motivated revision.

The diagnostic revision record turns diagnosis into a maintained methodological object. It also supports accountability: later actors can reconstruct which practical field was believed to exist at a given time and how that belief changed. This is especially important when evaluation occurs after conditions have shifted substantially.

Proposition 11.59 (Uncertainty-explicit diagnosis). *A practical diagnosis is methodologically stronger when materially relevant uncertainty is located within specific diagnostic components, linked to its practical significance, and connected where possible to learning, protection, monitoring, or revision pathways.*

The eight diagnostic movements developed in this section jointly produce a revisable reconstruction of the practical field. Situation mapping specifies the field; actor and relation mapping identify positions and consequential connections; constraint and capacity mapping reconstruct the structure of practical possibility; historical and institutional diagnosis explain how that structure has formed and is reproduced; uncertainty mapping records the limits and fragilities of the reconstruction. The resulting diagnosis does not determine what should be pursued. It provides the structured practical object within which ends and evaluative standards can be specified with greater discipline. Section 285 therefore turns from diagnosis to *Goal and Criterion Specification*, examining how practical orientations become explicit goals, multiple criteria, thresholds, trade-offs, and revisable evaluative structures.

11.3 Situated Formation of Practical Orientations and Criteria

The role of this section is to specify how application-dominant praxis can acquire sufficient evaluative orientation for decision without presuming that goals, criteria, or thresholds possess a universal form. Its objective is to treat practical orientations and evaluative criteria as historically situated and relationally conditioned objects whose content, authority, degree of explicitness, and mode of comparison can differ across practical fields. The discussion proceeds through historical-relational formation, normative provenance, plural orientations, situated criteria, local threshold construction, partial comparability, feasibility and protection conditions, and revision of the evaluative frame. The method is meta-methodological: it identifies dimensions that a practical inquiry may need to make explicit while leaving their substantive specification to the history, relations, institutions, affected positions, and normative commitments of the particular field.

Application-dominant praxis can begin with many kinds of orientation. A statutory mandate, emergency obligation, inherited institutional commitment, affected-subject claim, collective aspiration, protective principle, repair obligation, open-ended search for improvement, or attempt to preserve future possibility can each organize action. Some contexts support explicit goals and measurable criteria. Others contain contested orientations whose content is still being negotiated. Still others require exploratory action before a stable goal can be formulated. A meta-framework should

therefore provide an architecture for making evaluative commitments traceable without converting one historically specific decision grammar into a universal procedure.

Definition 11.60 (Situating practical orientation). A *situated practical orientation* is a historically and relationally located direction, commitment, protection, obligation, aspiration, or valued condition that helps organize practical judgment within a specified field and whose standing depends on identifiable sources, affected positions, institutions, histories, and conditions of revision.

A goal is one possible articulation of a situated practical orientation. A criterion is one possible representation through which an orientation becomes assessable. A threshold is one possible boundary or trigger. Their methodological status therefore depends on the practical setting. The section uses these familiar objects while treating them as local constructions within a broader evaluative frame.

Definition 11.61 (Evaluative frame). An *evaluative frame* is the revisable configuration of practical orientations, criteria, protected conditions, comparison rules, temporal horizons, affected positions, authority relations, and uncertainty assumptions through which actions or consequences are interpreted for a particular practical purpose.

Table 11.3 summarizes the principal dimensions of this meta-level architecture. The rows are an analytical repertoire. A practical field can instantiate only the dimensions that are materially relevant, and the form taken by each dimension can change through the history of the intervention.

The architecture in Table 11.3 shifts the methodological emphasis from fixing a universal list of goals to documenting how practical orientation is constituted and revised. A numerical target, a qualitative protection, an institutional duty, a procedural requirement, and an open-ended commitment to preserve future options can all occupy legitimate positions within the framework when their standing is made explicit.

11.3.1 Historical and Relational Formation of Practical Orientation

Practical orientation emerges within a history. Its content can depend on prior commitments, institutional trajectories, social expectations, accumulated harms, established capacities, legal arrangements, ecological conditions, or earlier interventions. A goal formulated at one historical moment can therefore lose relevance, acquire new meaning, or conflict with obligations that were previously weakly visible. The methodological task is to recover enough of this formation process that the orientation does not appear as an exogenous scalar attached to an otherwise complete decision problem.

A practical field can also contain several relational positions from which different orientations become intelligible. An implementing institution can emphasize continuity; an affected group can emphasize repair; a regulator can emphasize protection; a local practitioner can emphasize workable coordination; a future-facing planning process can emphasize option preservation. These orientations need not be reduced immediately to one objective. Their relational location is part of the practical infor-

Table 11.3: Meta-level dimensions for the situated formation of practical orientations and criteria.

Dimension	Analytical object	Local question	Typical reopening condition
Historical formation	Origin and trajectory of practical orientation	Through which events and relations did the orientation acquire practical standing?	Changed field, newly recovered history, altered mandate
Normative provenance	Sources of value, obligation, authority, and protection	Whose commitments are represented, with what standing and contestability?	New affected position, conflict of authority, revised obligation
Plural orientation	Coexisting or layered practical directions	Which orientations re-inforce, sequence, constrain, or remain in tension with others?	Newly visible conflict or changed temporal priority
Situated criteria	Representations used for assessment	Which features of the practical object are made assessable, and what remains outside the representation?	Proxy failure, scale mismatch, changed object
Thresholds and triggers	Local boundaries for action or review	Under which conditions is a threshold meaningful and authorized?	Changed baseline, regime shift, measurement drift
Partial comparability	Relations among heterogeneous values	Which comparisons are warranted without forcing complete commensuration?	Emergent value form, contested conversion, changed affected position
Feasibility and protection	Capacity, authority, rights, obligations, safety, material limits	Which practical directions remain reachable and admissible under current conditions?	Capacity change, legal change, new risk or protection claim
Frame revision	Evaluative architecture through time	Which events require reinterpretation, reauthorization, or reconstitution of the frame?	New evidence, performative change, failure, critical transition

mation required for responsible comparison.

Definition 11.62 (Orientation-formation record). An *orientation-formation record* identifies the events, relations, affected positions, institutional sources, normative commitments, temporal horizons, and uncertainties through which a practical orientation acquired its current form and standing.

The record can be compact. Its purpose is traceability rather than exhaustive genealogy. Where the orientation is routine and uncontested, a statutory or organizational source can be sufficient. Where the orientation is disputed or historically burdened, deeper reconstruction can be required. The appropriate depth therefore depends on practical consequence and contestation.

The same framework accommodates emergent orientation. Some interventions begin with a broad direction such as exploration, stabilization, protection, learn-

ing, or restoration of practical capacity. More specific goals can be generated through diagnosis, participation, experimentation, or changed circumstances. A meta-methodology should preserve this possibility because premature specificity can close useful paths before the field is sufficiently understood.

11.3.2 Normative Provenance and Standing

A practical orientation carries normative provenance. The provenance concerns the sources through which a value, obligation, protection, or aspiration becomes relevant to action. These sources can include law, institutional mandate, prior agreement, affected-subject testimony, professional responsibility, ethical commitment, public deliberation, historical repair, or another locally justified basis.

Normative provenance and practical authority can diverge. A formally authorized institution can possess decision power while affected subjects possess distinctive knowledge of consequence. An expert body can possess technical competence while lacking authority to determine distributive priorities. A legal rule can impose a protection while leaving implementation details open. Methodological clarity therefore benefits from recording several forms of standing rather than compressing them into one variable.

Definition 11.63 (Normative-standing profile). A *normative-standing profile* records the sources, scopes, affected positions, authority relations, contest routes, and revision conditions associated with the practical commitments used in a decision process.

The profile can reveal that a disagreement concerns different kinds of standing. One actor can dispute the empirical means to an agreed end; another can dispute who has authority to define the end; a third can dispute whether the proposed category recognizes the affected relation at all. These disagreements call for different responses. Additional data can help the first, while participation, legal interpretation, institutional redesign, or ethical deliberation can be required for the others.

11.3.3 Plural and Layered Practical Orientations

Practical fields often contain several orientations that operate at different layers. Some concern immediate protection, others capability formation, institutional continuity, distributive consequences, procedural legitimacy, long-horizon resilience, or preservation of future options. Their relations can be reinforcing, sequential, conditionally conflicting, or only partially comparable.

A layered representation can be preferable to a single aggregated objective. Protective conditions can define a boundary within which exploratory learning occurs. A long-horizon orientation can constrain short-horizon optimization. A procedural commitment can govern how substantive goals are revised. A repair obligation can coexist with a generative orientation toward new capacities. The architecture therefore permits hierarchy, partial ordering, conditional precedence, and unresolved plurality where those structures better fit the field.

Definition 11.64 (Orientation architecture). An *orientation architecture* is a representation of the relations among coexisting practical orientations, including reinforcement, precedence, conditional dependence, protected status, tension, partial compa-

rability, and conditions under which their relations can change.

An orientation architecture can remain qualitative. Formal multi-objective or partial-order representations become useful only when their semantics are justified. The broader methodological requirement is to avoid turning unresolved plurality into a fictitious common scale merely because a later decision method expects scalar input.

11.3.4 Criteria as Situated Representations

Criteria translate selected aspects of an evaluative frame into objects that can support practical judgment. Their role resembles other representations in GRE: they make some features visible and actionable while compressing others. A criterion can be quantitative, categorical, relational, historical, procedural, legal, interpretive, or mixed.

A criterion therefore requires an identifiable relation to the practical orientation it is intended to represent. Access can be represented through travel time, affordability, legal eligibility, linguistic intelligibility, practical usability, network reach, or combinations of these. Each choice constructs a different object of assessment. The criterion gains methodological force when the link between representation and orientation is explicit enough to examine whether the representation remains adequate.

Definition 11.65 (Situated evaluation criterion). A *situated evaluation criterion* is a contextually justified representation used to assess an action, history, relation, process, or consequence relative to one or more practical orientations within a specified scope and temporal horizon.

Criteria can also be distributed across methods. Statistical indicators can represent some features, historical reconstruction can represent others, and affected-subject interpretation can identify consequences that are poorly captured by administrative data. Methodological pluralism therefore extends to evaluation itself. A practical design can use several criteria with different epistemic forms while preserving their distinct evidential bases.

Criterion-object fit should be reconsidered when the practical object changes. An indicator suitable during stable implementation can become misleading after a classification change, institutional reorganization, technological transition, or intervention-induced adaptation. Revision of the criterion can then be part of revision of the practical frame rather than a minor measurement adjustment.

11.3.5 Thresholds and Trigger Conditions

Thresholds can be useful where the practical field supports a defensible boundary or trigger. Examples include legal eligibility, safety limits, escalation conditions, resource minima, review dates, stopping rules, or model-specific transition indicators. Their role is local. A threshold acquires meaning through the process that defines the represented quantity, the consequences attached to crossing the boundary, and the authority through which the trigger becomes actionable.

A threshold can therefore be descriptive, normative, institutional, or operational. These functions should remain distinguishable. A statistically unusual value does

not automatically constitute a normative violation. A legal threshold can bind action even when the underlying empirical quantity changes smoothly. A protective threshold can be intentionally conservative. An adaptive trigger can be revised as learning changes the model.

Definition 11.66 (Threshold provenance profile). A *threshold provenance profile* records the represented quantity or condition, source of the boundary, practical function, affected positions, uncertainty, authority, and conditions under which the threshold should be reconsidered.

Thresholds can become especially fragile when the baseline or regime changes. A trigger calibrated under one historical configuration can lose meaning after the observation system, population, institution, or dynamical regime changes. Sections 11.11 and 11.26 develop these transition and temporal-transfer issues at the level of decision architecture.

11.3.6 Partial Comparability and Heterogeneous Value

Practical comparison does not require complete commensurability. Some evaluative dimensions can be ordered locally, some can be converted under explicit conventions, and others can remain only partially comparable. The framework therefore permits scalarization, vector comparison, lexicographic protection, partial ordering, deliberative judgment, or preservation of incomparability where each is justified.

This distinction matters because conversion is itself a practical act. Assigning a monetary equivalent, score, rank, or common utility can create a powerful coordination device while also suppressing dimensions that the conversion does not preserve. GRE later treats heterogeneous value conversion as a substantive economic problem. At the present meta-methodological level, the requirement is narrower: the decision architecture should record when comparison depends on a conversion rule and what remainder that rule leaves outside the common scale.

Definition 11.67 (Comparability profile). A *comparability profile* records which evaluative dimensions can be compared directly, which require an explicit conversion or aggregation rule, which admit only partial ordering, and which remain deliberately uncollapsed within the current practical frame.

Partial comparability can support action. A project can identify dominated alternatives, protected conditions, acceptable regions, or priority relations without producing one global ranking. This possibility is important for a meta-framework because many historically situated decisions contain legitimate value heterogeneity that should remain visible after method selection.

11.3.7 Feasibility, Authority, Protection, and Constraint

Practical orientations operate within fields of capacity and constraint. A desired transformation can be materially infeasible, institutionally unauthorized, legally restricted, ethically inadmissible under the adopted commitments, or dependent on capacities that do not yet exist. These conditions have different meanings and should remain analytically distinct.

Feasibility concerns whether an action or trajectory is reachable under represented conditions. Authority concerns whether relevant actors possess standing to authorize or implement it. Protection concerns conditions whose preservation constrains action because of rights, safety, responsibility, ecological boundaries, or other justified commitments. Capacity concerns whether the field contains the resources, relations, knowledge, coordination, and institutional ability required for the contemplated transformation.

Definition 11.68 (Practical admissibility profile). A *practical admissibility profile* records the material feasibility, institutional authority, protective conditions, required capacities, and salient uncertainties that condition whether a contemplated practical direction can be pursued within the current field.

The profile can change through intervention. Capability building can make a previously latent action feasible. Legal reform can change authority. A new affected position can reveal a protection not previously represented. Resource depletion can foreclose a pathway. This reinforces the need to treat goal and criterion architecture as historically evolving rather than as fixed input to the rest of the chapter.

11.3.8 Revision and Reconstitution of the Evaluative Frame

Evaluative revision can take several forms. A criterion can be recalibrated while the underlying orientation remains stable. A practical orientation can be reinterpreted after new historical knowledge. A protected condition can acquire greater standing after an affected position becomes visible. A goal can be abandoned after its generative consequences become unacceptable. An entire evaluative frame can be reconstituted when the practical field changes sufficiently that the previous grammar of assessment no longer fits.

Definition 11.69 (Evaluative-frame revision). An *evaluative-frame revision* is a documented change in the practical orientations, criteria, comparison rules, protected conditions, temporal horizons, authority relations, or affected positions through which a decision or intervention is assessed.

Revision requires provenance because changing criteria can otherwise obscure failure or weaken accountability. A revised frame should identify the event or argument motivating the change, the positions involved, the scope of the revision, its relation to earlier commitments, and whether previous decisions require reinterpretation. This does not require a single formal protocol. The documentation depth should reflect the consequence of the change.

The distinction between revision and strategic drift is practical rather than purely semantic. Revision is methodologically defensible when its reasons remain available for scrutiny and when materially affected positions can contest the change through appropriate channels. Strategic drift occurs when criteria are adjusted mainly to preserve a preferred conclusion without adequate disclosure or justification. Traceability therefore becomes part of evaluative integrity.

Proposition 11.70 (Situated evaluative formation). *Within application-dominant praxis, goals, criteria, thresholds, and comparison rules are methodologically stronger when their historical formation, relational location, normative provenance, practical*

scope, and revision conditions remain explicit enough to support the decision being made. Their useful specification need not take the same form across different histories or relational fields.

Proposition 11.70 defines the meta-level role of this section. The framework does not require every practical field to produce a fully specified objective function before action. It requires the evaluative commitments that materially organize action to remain proportionately visible, situated, and revisable. Section 11.4 turns to the corresponding epistemic problem: how an inherited and evolving state of knowledge can warrant practical commitment without reproducing the evidence epistemology and evidence-generation methods already developed in Parts II and III.

11.4 Epistemic Conditions of Practical Commitment

The role of this section is to define the interface between knowledge and practical commitment within application-dominant praxis. Its objective is deliberately narrower than a general epistemology of evidence. Chapter 5 developed evidential access, representation, uncertainty, performativity, machine-mediated knowledge, revisability, and epistemic justice, while Part III developed research designs through which evidence can be generated, interpreted, triangulated, and validated. The present section begins after some epistemic state has already been produced and asks how that state can enter consequential action. The discussion proceeds through inherited epistemic states, epistemic events and uptake, claim-to-commitment traceability, commitment-relative sufficiency, evidential burden, conflict and protected uncertainty, temporal validity, performative recursion, model plurality, and re-opening conditions. The method is meta-methodological: it specifies conditions for responsible translation from warranted claims to practical commitment while preserving the plurality of evidential and research methods developed earlier in the book.

This distinction is important for the architecture of Chapter 11. Evidence collection is not treated here as a subordinate stage of decision engineering. A field can be investigated through statistical, historical, ethnographic, institutional, participatory, legal, computational, or mixed methods, and each can produce different forms of warranted claim. Application-dominant praxis receives those claims together with their provenance, uncertainty, scope, and disagreements. The practical question is then whether a contemplated commitment is adequately supported given its depth, reversibility, temporal horizon, affected positions, and possible consequences.

Definition 11.71 (Inherited epistemic state). An *inherited epistemic state* is the versioned configuration of warranted claims, observations, interpretations, uncertainties, disagreements, model assumptions, source provenance, and recognized absences that a practical process receives from prior or ongoing inquiry at a specified historical moment.

The inherited epistemic state is not assumed to be complete or internally homogeneous. It can contain quantitative estimates alongside historical interpretations, legal findings, local knowledge, contested classifications, model ensembles, and acknowledged unknowns. Its function is to preserve what is currently known and how

Table 11.4: Meta-level interface between epistemic states and practical commitment.

Interface	Primary object	Practical question	Possible response
Epistemic inheritance	Claims, interpretations, uncertainty, provenance	Which parts of the current knowledge state bear on the contemplated commitment?	Scope restriction, synthesis, additional inquiry
Epistemic uptake	Recognition, interpretation, communication, institutional admission	Does an epistemic occurrence remain informational or alter the practical field through uptake?	Trace uptake, separate readout from transformation
Claim-to-commitment link	Inferential and normative chain	Through which judgments does a warranted claim support this action?	Explicit reasoning, preserved assumptions, contestability
Commitment-relative sufficiency	Evidence relative to consequence and reversibility	Is the epistemic state adequate for this depth and duration of commitment?	Proceed, stage, narrow, monitor, defer, return to research
Protected uncertainty	Conflict, missingness, unknown structure	Which uncertainties should remain visible inside the decision?	Branching histories, safeguards, bounded authorization
Temporal validity	Historical conditions of evidence	Does the evidential basis remain applicable after field or regime change?	Revalidation, transport qualification, reopening
Performative recursion	Evidence whose uptake changes later conditions	Does using the evidence modify the field from which later evidence will arise?	Versioned monitoring, causal separation, model revision
Model plurality	Competing representations and inferential structures	Which practical conclusions depend on one representation?	Robustness analysis, parallel models, conditional decisions
Reopening	New evidence, changed field, failed assumptions	Which epistemic changes require reconsideration of commitment?	Re-diagnosis, reauthorization, action-space revision

it is known well enough for the contemplated practical decision.

Table 11.4 summarizes the evidence-to-commitment interface developed in this section. The table should be read as a set of relations to examine rather than as a universal sequence.

The interface in Table 11.4 leaves the evidential methods themselves open. A practical process can inherit evidence from randomized experiments, observational studies, archival reconstruction, expert interpretation, participatory inquiry, legal analysis, simulation, or other methods without requiring their reduction to one evidential score. The decision architecture instead tracks the relation between the epistemic state and the commitment being contemplated.

11.4.1 Inherited Epistemic State

An application-dominant process rarely begins from epistemic zero. It inherits classifications, records, models, narratives, institutional memory, prior evaluations, practical experience, and unresolved disputes. These materials have different histories and evidential statuses. A decision process should therefore preserve their source and scope before attempting synthesis.

The inherited state can be represented through a dossier, evidence map, claim graph, model ensemble, historical narrative, legal record, or another form suited to the practical problem. Formal representation is optional. What matters is that consequential claims can be traced to the inquiry through which they acquired standing and that recognized gaps remain visible.

The relevant epistemic state is commitment-specific. A decision about a small reversible trial can require less settled knowledge than a long-duration institutional redesign. A decision about emergency protection can rely on a different combination of evidence and precaution than a decision about durable allocation. The same evidence base can therefore be adequate for one practical commitment and inadequate for another.

11.4.2 Epistemic Events and Practical Uptake

Knowledge enters practical history through events. Observation, interpretation, classification, recognition, publication, communication, recommendation, legal determination, expert judgment, or institutional acceptance can each change what actors know and can also change what actors do. The distinction between epistemic content and practical uptake is therefore central to application-dominant praxis.

Definition 11.72 (Epistemic event). An *epistemic event* is a historically located occurrence through which information, observation, classification, interpretation, recognition, communication, or model-mediated inference acquires a specified epistemic status within a practical field and can thereby affect later judgment, representation, or action.

An epistemic event can remain informational. A privately inspected monitoring report can revise an analyst's model without materially changing the wider field. The same report can become performative when publication changes expectations, eligibility, coordination, resource allocation, or institutional response. The practical record should distinguish these roles because later evidence can otherwise be misinterpreted as if it arose under unchanged conditions.

Definition 11.73 (Epistemic-uptake trace). An *epistemic-uptake trace* records the source, content, interpretive pathway, institutional or practical uptake, affected positions, and materially relevant consequences of an epistemic event.

The trace need not imply a formal operator. Section 11.12 develops operator, field, network, dynamical, and other representations for applications in which formalizing the transformation is useful. The present section requires only that the distinction between learning about the field and changing the field through epistemic uptake remain conceptually available.

11.4.3 Claim-to-Commitment Traceability

A warranted empirical or interpretive claim does not by itself specify a practical commitment. Action requires additional judgments concerning practical orientation, affected positions, admissible risk, authority, timing, scale, reversibility, and responsibility. The claim-to-commitment link should therefore remain traceable enough that these additional judgments do not disappear behind the authority of evidence.

Definition 11.74 (Claim-to-commitment chain). A *claim-to-commitment chain* is the documented sequence of epistemic, interpretive, normative, institutional, and practical judgments through which one or more warranted claims are used to support, qualify, stage, or reject a contemplated commitment.

The chain can include explicit assumptions. A forecast can support capacity preparation only under an assumption about transportability and a judgment about acceptable shortage risk. A causal estimate can support intervention only under assumptions about mechanism stability and a decision concerning distributive consequences. A historical analogy can support caution only through a stated interpretation of relevant similarity. Traceability makes these transitions available for criticism.

This architecture also preserves the difference between evidential disagreement and normative disagreement. More data can sometimes reduce the former. The latter can persist even when the parties accept the same evidence. A practical method that treats every disagreement as an information deficit can therefore misdiagnose the decision problem.

11.4.4 Commitment-Relative Epistemic Sufficiency

Epistemic sufficiency is relative to the commitment being considered. The framework does not assume one confidence threshold that licenses action across domains. It instead relates the required evidential support to practical consequence, reversibility, scale, duration, distribution of risk, capacity for monitoring, and availability of repair.

Definition 11.75 (Commitment-relative epistemic sufficiency). An epistemic state has *commitment-relative sufficiency* when its warranted claims, recognized uncertainties, provenance, and contestability are adequate for the depth and consequence of a specified practical commitment under the safeguards and revision capacities available in the field.

Sufficiency therefore need not mean certainty. A bounded pilot can be justified under substantial uncertainty when exposure is limited, monitoring is informative, rollback is credible, and affected positions are protected. The same evidence state can be inadequate for a deep and difficult-to-reverse intervention whose consequences are concentrated or whose failure cannot be repaired.

Sufficiency can also be conditional. Authorization can be granted for one stage while later stages remain contingent on additional evidence. A commitment can be restricted to selected populations or sites while transportability is investigated. The practical architecture can therefore convert epistemic uncertainty into staged authorization rather than forcing an all-or-nothing decision.

11.4.5 Commitment Depth and Evidential Burden

The relationship between epistemic burden and commitment depth is one of the central interfaces between research and action. Deeper interventions can alter institutions, subject positions, capacities, classifications, dependencies, or future action spaces. Longer commitments can expose later populations to assumptions made under earlier conditions. Hard-to-reverse commitments can make learning after implementation less capable of correcting error.

Proposition 11.76 (Escalating epistemic burden). *Where practical commitments become deeper, longer, more difficult to reverse, more distributively concentrated, or more dependent on uncertain mechanisms, the decision architecture should generally require correspondingly stronger justification, traceability, protection, monitoring, or staged authorization, subject to the urgency and opportunity costs of delay.*

Proposition 11.76 is deliberately conditional. Emergency action can make delay itself costly. Some harmful conditions persist precisely because institutions demand impossible certainty before intervention. The proposition therefore concerns proportionality of epistemic and protective architecture rather than a universal preference for caution.

The evidential burden can be distributed across several devices. Stronger prior evidence is one route. Greater reversibility, smaller scale, independent monitoring, explicit compensation, protected exit, and staged escalation can also reduce the practical consequences of epistemic error. Decision design can therefore respond to uncertainty by changing the commitment itself.

11.4.6 Conflict, Missingness, and Protected Uncertainty

Practical decisions often contain unresolved evidential conflict or missingness. Different models can disagree, administrative data can omit relevant relations, affected subjects can report consequences absent from aggregate indicators, and historical records can support competing interpretations. The meta-framework treats these conditions as part of the epistemic state rather than as defects that must always be erased before action.

Definition 11.77 (Protected uncertainty). *A protected uncertainty is a materially relevant uncertainty, disagreement, or recognized absence that remains explicitly represented in a practical decision because available inquiry has not warranted its resolution and because suppressing it could distort commitment, monitoring, or responsibility.*

Protected uncertainty can influence action in several ways. It can motivate branching scenarios, safeguards, staged commitment, wider participation, additional inquiry, or explicit contingency plans. It can also remain as an interpretive remainder when a decision must proceed under time pressure. The key requirement is that the unresolved status not be converted silently into a precise input merely to satisfy a formal model.

Missingness can itself be relationally generated. A group can be absent because the administrative system does not recognize it; an informal relation can be weakly recorded because institutions lack incentives to document it; a harm can remain in-

visible because the observation scale is too coarse. Research methodology in Part III addresses how such missingness can be investigated. Chapter 11 asks what practical burden remains while the missingness is unresolved.

11.4.7 Temporal Validity and Transport Conditions

Evidence has a historical location. A claim can be well supported for a population, institution, measurement regime, relation structure, or dynamical regime at one period and require revalidation after those conditions change. Practical commitment should therefore record the temporal and relational conditions under which evidence is being transported.

Definition 11.78 (Evidence-transport profile). An *evidence-transport profile* records the historical period, field conditions, population or relational structure, observation regime, institutional context, and mechanism assumptions under which evidence was generated, together with the similarities and differences relevant to its proposed practical use.

Transport can be straightforward when relevant conditions remain stable enough for the practical purpose. It can become difficult after institutional reform, technological change, population change, crisis, changing classification, prior intervention, or a possible regime transition. Section 11.11 develops the special case in which the stability of local response itself becomes uncertain near a qualitative transition.

Temporal validity also matters during long interventions. Evidence supporting initiation can age while implementation changes the field. A monitoring architecture should therefore identify which assumptions require periodic re-examination and which evidence remains historically anchored to an earlier configuration.

11.4.8 Performative Uptake and Recursive Evidence

Using evidence can change the world from which subsequent evidence is generated. A classification can change eligibility, a forecast can alter expectations, a public indicator can redirect organizational effort, and a recommendation can coordinate behavior. These effects create a recursive relation among evidence, decision, and later observation.

The practical architecture should therefore distinguish at least three moments: the epistemic claim before uptake, the process through which the claim becomes practically consequential, and the later evidence generated after the field has responded. The later evidence can still be informative, but its interpretation should account for the intervention or representational event that helped produce it.

Performative uptake can also change the relative support assigned to alternative histories. A forecast that triggers precaution can make the forecasted adverse history less likely. A public commitment can make a previously unlikely coordination history more accessible. Such reweighting is model-relative and need not be represented numerically. Where numerical history weights or transition kernels are useful, Section 11.12 provides the formal apparatus.

Proposition 11.79 (Recursive evidence use). *When the practical uptake of evidence materially changes the conditions that generate later evidence, evaluation should in-*

interpret subsequent observations as products of the changed history and preserve the uptake event within the causal and epistemic record.

This proposition is central to monitoring and adaptive revision. A model can appear to lose predictive accuracy because the intervention succeeded in changing the process it predicted. It can also appear to perform well because institutional reliance on the model helped create the pattern it forecast. The epistemic record should permit these possibilities to be distinguished where they matter.

11.4.9 Model Plurality and Decision Dependence

Application-dominant praxis can inherit several reasonable models of the same field. They can differ in boundary, variables, historical reconstruction, mechanism, scale, temporal resolution, uncertainty structure, or value-relevant outputs. A decision architecture should therefore ask which practical conclusions remain stable across models and which depend on one representation.

Model plurality need not be resolved by selecting one winner. Competing models can define a robustness family, support conditional decisions, motivate differentiated monitoring, or identify assumptions whose empirical investigation has unusually high practical value. Historical and interpretive representations can also participate in this plurality where they provide access to structures absent from formal models.

Proposition 11.80 (Plural updating in evolving decision spaces). *Where several defensible models support materially different practical conclusions, the decision process should preserve model dependence explicitly and connect later evidence to model comparison, action-space revision, or staged commitment in a form proportionate to the consequences of error.*

Model dependence becomes particularly important when the field can change because of the decision. An intervention can invalidate assumptions shared by several models or make a previously weak model more relevant. Model plurality is therefore historical rather than a one-time pre-decision exercise.

11.4.10 Reopening Conditions and Return to Research Praxis

Practical commitment does not close inquiry. An intervention can encounter evidence that contradicts its mechanism, reveal an affected position omitted from the original frame, cross into a different dynamical regime, generate a new action, or expose a representational failure. These events can require a return to research-dominant praxis before further commitment.

Definition 11.81 (Epistemic reopening condition). *An epistemic reopening condition is an event, discrepancy, uncertainty change, performative effect, model conflict, or field transformation that makes one or more assumptions supporting a practical commitment insufficiently warranted for continued use at the current depth of action.*

Reopening can occur at different depths. A local parameter can be recalibrated. A criterion can be revised. The diagnostic boundary can expand. A causal mechanism can be reconsidered. A model family can be retired. A deeper change can return the

project to historical, participatory, empirical, or theoretical inquiry before the action space is reconstructed.

The possibility of return is a constitutive feature of the architecture. Research-dominant and application-dominant praxis remain distinct in function, yet their histories can interleave. Application produces new evidence; research revises knowledge; revised knowledge changes practical commitment; practical commitment changes the field again. Chapter 11 therefore treats the evidence-to-action interface as recursive and historically open.

The next section develops decision analysis within this open epistemic architecture. The decision problem is not a fixed mapping from evidence to a pre-given action menu. It concerns historically situated subjects, evolving action spaces, multiple histories, revisable evaluative frames, and commitments whose evidential adequacy depends on what the commitment can generate.

11.5 Practical and Epistemic Situation Mapping

The role of this section is to provide a provisional map of the practical and epistemic situations within which application-dominant praxis may have to form commitments. Its objective is diagnostic rather than classificatory in a strong ontological sense: the section identifies dimensions that can change the adequacy of decision methods, the burden of evidence, the relevance of participation, the interpretation of uncertainty, and the design of revision or exit. The discussion proceeds through epistemic accessibility, probabilistic characterizability, model agreement, historical transport, dynamical condition, critical-transition uncertainty, stakes and reversibility, reflexivity, relational heterogeneity, power and responsibility, compound situation profiles, and revision of the map itself. The method is comparative and meta-methodological. The dimensions are offered as an open analytical repertoire rather than as an exhaustive taxonomy of practical reality.

A decision situation can be difficult for several different reasons. Information may be sparse even when the underlying process is comparatively stable. Probabilities may be estimable while consequences are difficult to reverse. Models may disagree because they represent different mechanisms rather than because one is simply erroneous. A field may be well observed and nevertheless evolve so rapidly that a stable decision representation expires before action is completed. A decision can also become performative when its announcement, classification, forecast, or implementation changes the relations from which later evidence is generated. Treating these conditions as one undifferentiated category of “uncertainty” can conceal the methodological differences among them.

The present map therefore uses dimensions rather than mutually exclusive classes. A practical situation can be high-stakes and well observed, deeply uncertain and readily reversible, turbulent and low-stakes, near a possible critical transition while remaining institutionally controllable, or strongly performative under otherwise stable conditions. Several dimensions can change simultaneously. Their practical relevance also depends on the action under consideration: an uncertainty that is negligible for a reversible pilot can become decisive for a long-duration institutional commitment.

Table 11.5: Illustrative dimensions for practical and epistemic situation mapping.

Dimension	Illustrative range	Methodological significance
Epistemic accessibility	Directly observed; partially observed; weakly accessible; materially inaccessible	Affects evidential burden, inference, monitoring, and the role of situated or tacit knowledge
Probabilistic characterizability	Calibrated risk; unstable probabilities; ambiguous distributions; deep uncertainty	Affects the usefulness of expected-value, probabilistic, robust, and adaptive procedures
Model agreement	Convergent models; parameter disagreement; structural disagreement; poorly formed models	Affects reliance on single-model inference, model ensembles, stress tests, and qualitative comparison
Historical transport	Strongly comparable; partially transported; structurally shifted; weakly transportable	Affects whether past evidence and estimated mechanisms remain relevant to present commitment
Dynamical condition	Comparatively stable; rapidly changing; turbulent; transitional	Affects decision horizon, update frequency, representation stability, and the value of staged commitment
Critical-transition condition	No material indication; plausible proximity; model disagreement; active transition	Affects local extrapolation, sensitivity, hysteresis analysis, and transition-sensitive monitoring
Stakes and loss structure	Bounded consequence; high consequence; concentrated harm; catastrophic tail possibility	Affects review depth, redundancy, burden of justification, and responsibility design
Reversibility	Readily reversible; costly to reverse; path dependent; strongly irreversible	Affects experimentation, staging, option preservation, compensation, and exit architecture
Time pressure	Deliberative horizon; constrained horizon; rapidly closing window; emergency	Affects feasible inquiry, role of expertise, delegation, and the cost of delay
Reflexivity / performativity	Weak feedback; behaviorally responsive; institutionally performative; strongly self-altering	Affects deployment evaluation, model revalidation, and interpretation of post-decision evidence
Relational heterogeneity	Similar positions; differentiated positions; conflicting dependencies; strongly unequal consequences	Affects representation, participation, distributional analysis, and comparison across subjects
Power and responsibility	Dispersed; concentrated; delegated; distributed with possible responsibility gaps	Affects authorization, contestability, review, accountability, and persistence of decision authority

Definition 11.82 (Practical–epistemic situation profile). A *practical–epistemic situation profile* is a revisable representation of the conditions materially relevant to practical judgment, including the accessibility and transport of knowledge, the character of uncertainty, the dynamical and temporal condition of the field, the stakes and reversibility of commitment, the distribution of power and responsibility, and the degree to which observation or decision can alter the field itself.

Definition 11.82 does not imply that every project should measure every dimension. The profile is a prompt for discriminating among practical conditions that can require different methodological responses. Some dimensions can be quantified; others can be represented through qualitative ranges, historical reconstruction, institutional analysis, or explicit statements of unresolved uncertainty. A profile can also remain incomplete when the information required to characterize the situation is itself unavailable.

Table 11.5 summarizes an illustrative set of dimensions. The ranges in the table are descriptive anchors rather than calibrated scales. Their purpose is to make methodological assumptions visible before a decision process selects a particular model or procedure.

11.5.1 Epistemic Accessibility and Observability

Epistemic accessibility concerns the degree to which the practically relevant configuration can be observed, reconstructed, or inferred with the available epistemic infrastructure. Accessibility is broader than data volume. A field can generate extensive data while leaving important mechanisms, relations, histories, or affected positions weakly observed. Conversely, a small number of well-situated observations can sometimes disclose a practically decisive mechanism.

The distinction developed in Chapter 5 between manifestation and underlying relational structure remains important here. Observable indicators can provide access to selected manifestations while the practical object of interest depends on relations that are only indirectly represented. A monitoring system can observe service use while missing informal exclusion; a network measure can represent connections while omitting the meaning of dependence; an institutional record can document formal authority while practical influence remains distributed elsewhere.

Accessibility can therefore be represented through several channels: direct measurement, archival evidence, historical reconstruction, testimony, expert recognition, model-mediated inference, participatory mapping, and other forms of access appropriate to the field. The practical question is not whether one channel is intrinsically superior. It is which aspects of the decision object remain visible or invisible through the available combination.

A decision process can also alter observability. Classification can bring a previously informal relation into administrative view. Intervention can create new data streams while destroying older comparability. A powerful institution can make some actors easier to observe by requiring reporting while pushing other activity outside the formal system. Situation mapping should therefore distinguish present accessibility from the accessibility likely to exist after commitment.

11.5.2 Probabilistic Characterizability and Deep Uncertainty

Uncertainty admits several practical forms. Some decisions concern outcomes whose probability distributions can be estimated with sufficient stability for the intended use. Other decisions involve uncertain parameters within an accepted model family. Still others involve disagreement about models, causal structures, future conditions, relevant outcomes, or evaluative criteria. The methodological significance lies in the relation between the kind of uncertainty and the decision procedure being considered.

Research on decision making under deep uncertainty provides one neighboring family of approaches for cases in which actors cannot confidently specify a single probability model or long-horizon future and therefore examine robustness, adaptivity, pathways, and alternative futures (Marchau et al. 2019). GR can learn from such approaches without treating their categories as exhaustive or assuming that deep uncertainty is the only form of epistemic difficulty relevant to practical judgment.

The situation map should therefore record whether probability statements are empirically calibrated, structurally assumed, elicited from experts, generated through simulation, or used only as exploratory weights. It should also record which uncer-

tainties remain outside the probabilistic representation. A numerical probability can be highly informative under one evidential regime and misleading when its precision obscures unresolved model or historical uncertainty.

Deep uncertainty should likewise remain a scoped description. Some aspects of a practical problem can be deeply uncertain while others are well established. A decision can therefore combine probabilistic analysis for one component with scenario reasoning, historical interpretation, or qualitative safeguards for another. Methodological composition becomes more important as the uncertainty structure becomes heterogeneous.

11.5.3 Model Agreement and Representational Plurality

Model disagreement can arise from different parameter estimates, different structural assumptions, different boundaries, different temporal scales, different interpretations of the relevant subject, or different representational purposes. These forms of disagreement should not be collapsed into one model-error term. Two models can disagree because one represents short-horizon prediction while another represents an intervention mechanism; a historical reconstruction and a dynamical model can appear inconsistent because they preserve different kinds of information.

Situation mapping should therefore ask what each representation is intended to disclose and which practical claims depend on agreement among them. Convergence across models can increase confidence only when the models provide meaningfully distinct tests of the same claim. Agreement among several models built from the same assumptions, data, or boundary choices can provide less independent support than their number suggests.

Representational plurality can also remain unresolved. In some practical settings, the appropriate response to model disagreement is further research. In others, a decision window can close before disagreement is resolved. Robust comparison, sensitivity analysis, staged commitment, or explicit preservation of dissenting representations can then become relevant candidate responses. Their adequacy depends on stakes, reversibility, and the consequences of acting under the wrong model.

11.5.4 Temporal Transport and Historical Drift

Evidence is generated in time. Its practical relevance depends on whether the relations, institutions, classifications, technologies, populations, and mechanisms that supported an earlier inference remain sufficiently comparable to the present field. Temporal transport is therefore a dimension of the decision situation rather than a technical afterthought.

Historical drift can occur gradually or discontinuously. A measured relationship can weaken as behavior adapts. A legal reform can change the meaning of an administrative category. A new technology can alter the feasible action space. An earlier intervention can change who remains observable. A public model can alter expectations and thereby change the process that later data represent. These changes can matter even when standard predictive diagnostics show only modest statistical drift.

A situation profile should consequently identify the historical period from which

decisive evidence is drawn, the transformations that occurred between evidence generation and current use, and the mechanisms assumed to transport. The confidence attached to a past result can then be separated from the confidence attached to its present applicability.

11.5.5 Dynamical Condition and Turbulent Practical Fields

The dynamical condition of a practical field concerns the stability of the relations required to maintain a useful decision representation over the relevant horizon. Some fields change slowly enough that a model, institutional map, and action set remain comparatively stable while deliberation proceeds. Other fields change rapidly through interacting actions, information, institutional responses, technological shifts, or external events.

The present framework uses *turbulent practical field* as a provisional methodological description rather than as an assertion that social or economic systems obey the mathematical dynamics of fluid turbulence.

Definition 11.83 (Turbulent practical field). A *turbulent practical field* is a practical configuration in which decision-relevant states, relations, constraints, actors, information structures, or feasible actions change sufficiently rapidly and interactively that a stable representation of the decision environment cannot be presumed to remain adequate over the horizon required for ordinary plan–execute–evaluate control.

Definition 11.83 is intentionally modest. It provides a vocabulary for situations in which the decision problem evolves while being addressed. The designation can be inappropriate when rapid change is superficial or when the relevant mechanism remains stable. It should therefore be treated as a revisable diagnosis rather than a categorical property of a field.

Naturalistic decision-making research offers an important neighboring perspective because it studies how experienced decision makers recognize and act within complex real-world conditions where time pressure, changing cues, and expertise can matter materially (Klein 2008). GR does not infer from this literature that intuition should replace analysis. The relevance is narrower: some decision situations place practical weight on situated recognition and tacit expertise that is difficult to reconstruct through exhaustive option comparison within the available time.

Turbulent conditions can make short decision horizons, frequent re-situation, distributed observation, provisional commitments, and rapid responsibility-preserving revision more salient. These are candidate responses rather than fixed rules. A rapidly changing field can also require decisive long-horizon commitment when delay itself produces irreversible loss. Situation mapping should therefore describe the dynamical condition before prescribing a response.

11.5.6 Criticality and Regime Uncertainty

Critical-transition uncertainty concerns the possibility that a system is near a qualitative change in response regime. Section 11.11 develops this condition in detail after

robustness and adaptive decision-making have been introduced. The present subsection locates criticality within the wider situation map.

Possible proximity to a transition is analytically distinct from turbulence. A field can change rapidly without approaching a critical transition, and a system can approach a transition while its observable state appears comparatively stable. The distinction also matters for evidence. Ordinary local relationships can remain useful in a turbulent but regime-preserving condition, while apparently stable relationships can become fragile near a poorly observed transition.

Situation mapping should record the basis for any criticality claim, the models under which the claim arises, the indicators or mechanisms supporting it, the degree of disagreement among representations, and the consequences if the diagnosis is wrong. The absence of a reliable criticality indicator should remain visible rather than being replaced by a confident categorical label.

11.5.7 Stakes, Reversibility, and Time Pressure

Stakes, reversibility, and time pressure form distinct dimensions. A decision can be highly uncertain and low-stakes, comparatively predictable and catastrophic if wrong, highly consequential yet readily reversible, or moderately consequential but effectively irreversible because later correction is impossible. Time pressure adds another relation because further inquiry can itself consume an expiring opportunity.

High-stakes conditions therefore should not be treated as a single method class. The practical burden depends on who can be harmed, how harm is distributed, whether compensation or repair is possible, whether action creates long-duration dependency, and whether delay imposes its own costs. A safety-critical engineering decision, an emergency response, a reversible organizational pilot, and a constitutional institutional change can all be high-stakes in different ways.

Reversibility should likewise be represented relationally. An intervention can be reversible for the implementing institution while remaining irreversible for subjects who changed employment, residence, health, legal status, trust, or access in response to it. Section 11.25 later develops exit and rollback as historically situated processes rather than simple restoration.

Time pressure can increase the value of experienced judgment, pre-established protocols, delegation, and rapid sensing, while also increasing the risk of unreviewed authority or premature simplification. Situation mapping should therefore record both the cost of delay and the cost of insufficient deliberation.

11.5.8 Reflexivity and Performativity

A practical field is reflexive when representations, expectations, classifications, or announced decisions can influence the behavior of actors within the field. It is performative in the stronger practical sense used in this book when epistemic outputs enter institutional or relational processes and materially change the configuration that later generates evidence.

The degree of reflexivity matters for method selection. A quietly used diagnostic model can have limited behavioral effects, while a publicly announced forecast can

coordinate expectations. A classification can alter eligibility. A ranking can change resource allocation. A monitoring indicator can become a target that reorganizes behavior around its measurement. These effects can make post-deployment data endogenous to the decision system.

Situation mapping should therefore record who can observe the decision process, how outputs circulate, which actors can respond strategically or institutionally, and whether the response changes the validity conditions of the original model. This dimension connects directly to the boundary conditions developed later in Section 11.26.

11.5.9 Relational Heterogeneity and Position

Practical situations can contain subjects whose exposure, capacity, dependence, knowledge, and standing differ substantially. An aggregate model can describe average outcomes while concealing that one group bears the transition cost, another controls the decision, and a third receives most of the generated capacity. Relational heterogeneity therefore affects both epistemic adequacy and normative interpretation.

A situation profile can identify differentiated positions without presuming a single morally correct aggregation. Relevant distinctions can include decision authority, exposure to loss, dependency, access to alternatives, ability to exit, informational access, capacity to contest, and the historical relations through which the present positions were formed. Which distinctions matter depends on the decision and should remain open to revision.

Heterogeneity can also occur within formally similar categories. Two organizations with the same legal status can occupy different network positions. Two households with similar income can differ in care obligations, time constraints, housing stability, or access to institutional support. Situation mapping should therefore avoid treating administrative categories as complete representations of practical position.

11.5.10 Power and Responsibility Configuration

Decision conditions differ according to who can authorize action, shape the representation of the problem, control information, allocate resources, impose costs, revise rules, and terminate the intervention. These capacities can be distributed across several institutions or concentrated in one position. Their practical significance depends on both formal authority and effective relational capacity.

Power concentration is not automatically evidence of methodological failure. Some conditions can require concentrated coordination or temporary emergency authority. The situation map should instead identify the source, scope, duration, review structure, and self-reinforcing mechanisms of decision power where these are material. An authority that expands because each intervention creates new dependency differs from an authority whose scope remains bounded by the task that justified it.

Responsibility configuration should be mapped separately from power. A participant can possess technical influence without formal authorization; an institution can

hold formal responsibility while depending on a vendor or expert system it cannot meaningfully inspect; several actors can each satisfy their local duty while a system-level obligation remains unattended. These configurations prepare the responsibility-vacancy analysis in Section 11.26.

11.5.11 Compound Situation Profiles

Real decisions usually combine several dimensions. The practical significance of one dimension can change through its interaction with another. Deep uncertainty is more consequential when commitment is irreversible. Time pressure changes the value of additional evidence. Power concentration can become more problematic when uncertainty is high and contestability is weak. Performativity can make an otherwise well-calibrated prediction unstable after deployment.

Definition 11.84 (Compound situation profile). A *compound situation profile* is a situation representation in which several practical and epistemic dimensions are considered jointly because their interaction materially affects method selection, commitment depth, monitoring, responsibility, or revision.

A compound profile does not need to reduce the dimensions to one score. In many cases, the value of the profile lies precisely in preserving their distinct meanings. A decision can then be described, for example, as high-stakes, moderately observable, deeply uncertain with respect to long-horizon mechanisms, partially reversible, strongly performative, and institutionally concentrated. Such a description can guide methodological composition more transparently than a single label such as “complex” or “risky.”

Compound profiles can also change during intervention. Monitoring can improve observability; institutional reorganization can redistribute power; a pilot can reduce mechanism uncertainty; public controversy can increase performativity; a previously reversible decision can become locked in through investment or expectation. Situation mapping should therefore be versioned when the decision process extends through time.

11.5.12 Open Taxonomy and Revision

The dimensions developed in this section are examples drawn from the methodological problems already present in the book. They do not constitute a complete taxonomy of decision or epistemic situations. New technologies, institutional forms, forms of agency, environmental conditions, or research developments can make other dimensions practically important. A field can also require a distinction that has little relevance elsewhere.

Caution 11.85 (Open status of situation mapping). The practical–epistemic situation map is a revisable analytical aid. Its dimensions, boundaries, and descriptive ranges should be modified when they fail to represent materially relevant conditions of a practical field. The map should not be used as a closed ontology of decision situations or as an algorithm that determines method from classification alone.

Caution 11.85 preserves the meta-methodological status of the chapter. Situation mapping helps identify why a decision is difficult and what forms of inquiry or pro-

tection may deserve attention. It does not determine what should be valued, which method must be used, or which action is justified.

The next section develops a corresponding repertoire of situated considerations and candidate practical orientations. Those orientations remain defeasible and condition-sensitive. Their purpose is to make recurrent practical questions available for reflection without converting them into universal GR commandments.

11.6 Situated Considerations and Candidate Practical Orientations

The role of this section is to identify practical considerations that can become salient after a situation has been provisionally mapped, and to formulate a limited set of candidate orientations that may help organize judgment under specified conditions. Its objective is neither to supply a universal ethics of Generative Relational praxis nor to convert recurrent concerns into fixed decision rules. The discussion proceeds through the status of candidate orientations, epistemic and dynamical considerations, relational and distributional consequences, power and responsibility, value articulation, relational viability and transformation, reversibility and option preservation, methodological composition, proportionality of commitment, defeasibility, and methodological emergence. The method is normative-analytic and meta-methodological. Each orientation is treated as a possible reason for attention whose relevance, interpretation, priority, and relation to competing considerations depend on the historical-relational field.

The distinction between a *consideration* and a *principle* is important. A consideration identifies something that can matter to practical judgment: reversibility, distribution of harm, historical transport of evidence, concentration of authority, or loss of future options. A candidate principle proposes a defeasible orientation for responding to such a consideration under some conditions. Neither status implies universal priority. An orientation can be useful in one situation and weak, infeasible, or counterproductive in another.

Definition 11.86 (Candidate practical orientation). A *candidate practical orientation* is a provisional and defeasible reason for structuring inquiry, decision, or intervention in a particular way when specified features of a practical situation make that orientation relevant. Its standing remains open to contextual qualification, conflict with other considerations, empirical revision, and normative contestation.

Definition 11.86 deliberately avoids treating the orientations below as axioms of GR. Some can acquire stronger force through law, professional duty, explicit institutional mandate, prior agreement, or a separately defended normative theory. That stronger force comes from the relevant source of obligation rather than from inclusion in this chapter.

Table 11.6 gives an illustrative map from situation characteristics to considerations and possible orientations. The table is not a decision algorithm. Multiple orientations can become relevant simultaneously, and some can conflict. The practical task is to make those conflicts explicit enough for situated judgment, deliberation, or further inquiry.

Table 11.6: Illustrative practical considerations and defeasible candidate orientations.

Situation characteristic	Consideration	Possible orientation	Qualification
Deep or model uncertainty	Dependence of conclusions on contested futures or structures	Robust comparison, adaptive pathways, preserved learning capacity	Flexibility can be costly and may delay necessary commitment
High stakes	Consequences of error and unequal exposure	Greater review, redundancy, responsibility clarity, proportionate evidential burden	Urgency can limit feasible review; additional procedure can itself impose harm
Strong irreversibility	Path dependence and limited repair	Staged commitment, pilot action, option preservation where feasible	Some benefits require irreversible or large-scale commitment
Time pressure / turbulence	Rapidly changing cues and action space	Shorter review cycles, situated expertise, distributed sensing, rapid re-situation	Fast action can entrench error or authority if review disappears
Possible critical transition	Regime instability, amplification, hysteresis	Model plurality, transition-sensitive monitoring, staged action	Criticality diagnosis can itself be uncertain or model-dependent
Value plurality	Different affected positions and meanings	Co-articulation or co-creation of evaluative criteria where appropriate	Participation can be infeasible, unequal, strategic, or constrained by prior rights and duties
Strong power asymmetry	Dependency and self-reinforcing authority	Explicit review of power expansion, contestability, renewal or sunset conditions where suitable	Concentrated authority can sometimes be necessary for coordination or emergency response
Strong performativity	Decision output changes later evidence	Reflexive monitoring, deployment logging, model revalidation	Some performative effects are intended and beneficial
Distributed responsibility	Possible gaps among technical and institutional roles	Explicit responsibility architecture and identifiable duties	Shared responsibility need not be centralized in one actor
Relational fragility or lock-in	Persistence, dependence, exit, and future transformation	Examine viability, transformability, and conditions for safe dissolution	Persistence is not itself a good; some relations should end

11.6.1 Status of Candidate Orientations

Candidate orientations occupy an intermediate methodological status. They are more specific than a list of possible consequences because they indicate a direction for practical design, yet they remain weaker than universal obligations. Their force arises from the situation, the normative sources recognized in that field, the evidence available, and the consequences of alternative commitments.

This status is useful for a meta-framework because practical reasoning often requires guidance before a complete normative theory has been settled. A project can reasonably ask whether to preserve reversibility, widen participation, distribute monitoring, or limit the automatic extension of temporary authority without pretending that one answer applies to every domain. The chapter can make those recurrent questions visible while keeping their resolution open.

Candidate orientations can also conflict. Preserving options can reduce decisiveness. Broad participation can consume scarce time. Central coordination can improve response speed while increasing concentration of authority. Strong standardization can improve consistency while losing contextual meaning. A methodologically mature decision process should therefore preserve the conflict rather than defining one orientation as lexically prior by default.

Caution 11.87 (Defeasible status). The candidate orientations developed in this section are illustrative, defeasible, and incomplete. Inclusion in the present repertoire does not establish universal validity, priority, or applicability. Additional orientations can emerge from domain-specific practice, new forms of agency, institutional learning, or later theoretical development.

11.6.2 Epistemic Considerations

Practical judgment can begin by distinguishing what is observed, inferred, assumed, contested, inaccessible, and expected to change. This distinction supports an epistemic orientation toward traceability: consequential claims can be linked to their evidential sources, model assumptions, interpretive steps, and unresolved uncertainties at a depth proportionate to the decision.

Traceability does not imply that every form of knowledge must be converted into formal data. Historical interpretation, local knowledge, testimony, professional expertise, and tacit recognition can remain relevant epistemic forms. Their standing should be articulated through appropriate standards of credibility, provenance, corroboration, and scope rather than forced into a measurement regime that destroys their meaning.

A second consideration concerns epistemic diversity. Where materially different methods disclose different aspects of the field, premature reduction to one representational language can remove useful disagreement. A formal model can reveal sensitivity, consistency, and consequences across large scenario spaces; an institutional history can explain how the modeled categories acquired their present meaning; participants can disclose unrepresented dependencies; experienced practitioners can recognize patterns that are difficult to operationalize quickly.

The corresponding candidate orientation can be stated modestly: where several epistemic modes carry materially relevant information, practical reasoning may benefit from preserving their distinct contributions long enough for reciprocal comparison and correction. This is compatible with strong reliance on one method when the local problem justifies it.

11.6.3 Dynamical and Temporal Considerations

The dynamical state of the field can affect the appropriate rhythm of decision. A comparatively stable setting can support longer model-validation and planning cycles. A turbulent field can require shorter cycles of observation, commitment, and reassessment. A possible critical transition can increase the relevance of regime-sensitive monitoring and the cost of treating local regularities as stable.

Time itself creates trade-offs. Waiting can improve evidence while allowing an opportunity to disappear. Acting early can preserve an option while producing lock-in. A reversible intervention can generate information while changing the field from which that information is drawn. The practical question therefore concerns the relation among learning time, action time, consequence time, and the temporal horizon over which responsibility persists.

One candidate orientation is staged commitment where uncertainty is material

and the practical field permits meaningful stages. Staging can separate exploratory action from deeper institutional commitment and can create points at which evidence, goals, authority, or design are reconsidered. The orientation remains conditional because some transitions require coordinated scale, and some delay can increase rather than reduce harm.

11.6.4 Relational and Distributional Considerations

A practical decision generates and transforms relations as well as outcomes. It can create dependence, coordination, access, exclusion, recognition, obligation, trust, conflict, and new forms of institutional mediation. These relations can persist after the immediate output of the intervention has disappeared.

Distributional analysis should therefore extend beyond distribution of a scalar benefit or cost when the field requires it. Subjects can receive different capacities, different burdens of uncertainty, different possibilities of exit, and different exposure to later institutional decisions. A change that improves aggregate performance can still reorganize who must depend on whom, who can challenge a decision, and who acquires durable control over an infrastructure or classification system.

A candidate orientation follows: where relational consequences are material, evaluation may include the distribution of generated capacities, dependencies, obligations, and future options in addition to immediate outcomes. This orientation does not predetermine which distribution is just. It expands the object made available for normative and political evaluation.

11.6.5 Power and Responsibility Considerations

Practical interventions can create power by generating control over resources, classifications, information, access, coordination, standards, or future decision points. Temporary capacities can become self-reinforcing when the intervention makes later actors increasingly dependent on the institution that implemented it. Conversely, dispersing authority can make coordinated action impossible or leave responsibility without an effective bearer.

The meta-framework therefore does not adopt decentralization or power minimization as universal principles. A more limited candidate orientation is to examine the generation, persistence, scope, and review of decision power when the intervention materially changes them. Where authority expands beyond the conditions that initially justified it, review, renewed authorization, contestability, or sunset arrangements can become relevant possibilities.

Responsibility requires a related but distinct analysis. Delegation can be technically efficient while leaving unclear who must verify inputs, authorize deployment, investigate failure, repair harm, or preserve records. The candidate orientation is responsibility retention: consequential methodological delegation should be accompanied by an explicit account of the duties that remain attached to human and institutional positions. Section 11.26 develops responsibility vacancy as one boundary condition of formal decision systems.

11.6.6 Value Articulation and Co-Creation

Values can enter a practical process through law, institutional mandate, prior agreement, professional obligation, affected-subject claims, cultural interpretation, political authorization, or local deliberation. In some situations the relevant values are comparatively settled. In others, the intervention itself changes which values become visible or how different subjects interpret them.

“Value should be co-created” would therefore be too strong as a general GR principle. Co-creation can be especially relevant where values are plural, contested, under-articulated, or materially transformed by the intervention and where affected subjects possess knowledge or standing that the initial evaluative frame does not capture. It can be less relevant where a protected right already constrains the decision, where a narrow technical task has an authorized objective, or where an emergency leaves little time for extended deliberation.

A defeasible orientation can be stated more carefully: where practical value is materially plural, contested, or generated through the intervention process, the formation and revision of evaluative criteria may benefit from appropriate participation or co-articulation by differently situated subjects. The form of participation remains a separate design question and can range from consultation to delegated authority, co-design, representation, or later contestability.

This formulation also prevents co-creation from becoming a rhetorical substitute for responsibility. Inviting participation does not automatically legitimate a process, eliminate asymmetry, or transfer institutional obligations to affected subjects. The participation architecture developed later in Section 11.14 remains necessary.

11.6.7 Relational Viability and Transformation

The phrase *relational sustainability* can be useful only if its meaning is specified. Persistence, viability, and normative desirability are different properties. A relation can persist because exit is costly or coercively blocked. A relation can be viable for one participant while depleting another’s capacity. A normatively valued relation can be temporarily fragile. Practical judgment therefore should not treat persistence or sustainability as an unconditional good.

Definition 11.88 (Relational viability). *Relational viability* is the capacity of a specified relational configuration to continue performing or reproducing specified functions or capacities over a specified horizon under stated conditions. The concept is descriptive until the relevant functions, subjects, horizon, and normative standing of continuation have been specified.

Definition 11.88 keeps viability separate from approval. The practical question can concern preservation, transformation, managed dissolution, or replacement. In some cases an intervention should preserve a cooperative relation; in others it should reduce a coercive dependency or dismantle an institution whose persistence blocks other possibilities.

A candidate orientation is therefore broader than relational sustainability: when relations are materially changed by a decision, practical judgment may examine their persistence, viability, transformability, dissolution costs, and effects on the capacities

of differently positioned subjects. Which of these properties should be promoted remains a situated normative question.

This orientation also helps with uncertainty. Under a turbulent or transitional condition, preserving the current configuration may be neither feasible nor desirable. The relevant concern can instead be preservation of selected capacities through transformation: access to basic resources, ability to coordinate, capacity to contest, practical alternatives, institutional memory, or other locally justified conditions. The choice among these capacities should remain explicit rather than hidden under the generic word “sustainability.”

11.6.8 Reversibility, Option Preservation, and Learning

Reversibility can become salient when uncertainty is large, consequences are difficult to predict, or the intervention is expected to generate new information. Preserving the ability to revise can reduce the cost of model error and allow learning to alter later commitment. Adaptive planning traditions provide one neighboring methodological family in which strategies include monitoring and future adjustment under deep uncertainty (Marchau et al. 2019).

The corresponding orientation should remain conditional. Option preservation can impose real costs. Maintaining redundant infrastructure, delaying standardization, or preserving multiple pathways can consume resources that could otherwise improve present outcomes. Some achievements require commitment deep enough to close alternatives. A framework that always maximized optionality would simply substitute one universal value for another.

A more modest formulation is that unnecessary destruction of future action possibilities deserves explicit consideration when uncertainty is material and future learning is expected to change the quality of judgment. The word *unnecessary* keeps the orientation tied to the practical field rather than elevating option preservation into an absolute principle.

Learning should likewise be understood broadly. A pilot can generate statistical evidence, but action can also generate institutional knowledge, reveal hidden relations, expose capacity constraints, or change the meaning of the problem. A learning-oriented intervention should therefore specify what kind of epistemic event would justify continuation, revision, escalation, or withdrawal.

11.6.9 Methodological Composition and Reciprocal Correction

Formal, quantitative, historical, interpretive, naturalistic, participatory, and experimental methods can contribute different forms of discipline to practical judgment. Formal and natural-scientific methods are especially valuable for making assumptions explicit, maintaining internal consistency, operationalizing variables and mechanisms, comparing counterfactuals, exploring large possibility spaces, and supporting empirical testing or calibration where the field permits it. Their limitations arise when representation omits materially relevant meanings, historical transformations, normative inputs, tacit expertise, institutional responses, or model-changing feedback.

Historical and interpretive approaches can preserve provenance, context, meaning, institutional memory, and transformations that resist compact formalization. Naturalistic approaches can disclose how experienced practitioners recognize patterns and act under complex field conditions (Klein 2008). Participatory methods can reveal affected positions, local knowledge, disagreement, and practical consequences that centralized models fail to represent. These modes also have limitations: interpretations can be difficult to compare operationally, expertise can be biased or overgeneralized, participation can be unequal or strategic, and local knowledge can transport poorly across contexts.

The resulting methodological pluralism should not be reduced to a ritual requirement that every project use every method. The candidate orientation is dialectical in a limited methodological sense: where materially different methods provide relevant access, they can be composed so that their disagreements, blind spots, and assumptions become objects of reciprocal correction rather than being forced prematurely into one representational language. Triangulation research likewise cautions that combining methods can produce convergence, inconsistency, or contradiction that still requires interpretation (Jick 1979; Mathison 1988).

Methodological composition is therefore a design problem. A formal model can identify a sensitive parameter that directs historical inquiry. Participant testimony can reveal a missing relation that requires the model boundary to change. A naturalistic expert can identify a pattern that simulation later tests. A failed prediction can motivate institutional reconstruction. The composition can evolve as the practical field generates new evidence and new methodological needs.

11.6.10 Proportionate Commitment and Review

The practical burden of evidence, deliberation, documentation, review, monitoring, and responsibility can reasonably depend on the depth of commitment. A short, reversible, low-stakes intervention does not necessarily require the same methodological architecture as a long-duration, high-stakes, institutionally deep, or difficult-to-reverse transformation.

A candidate orientation of proportionality can therefore connect situation mapping to method design. Greater stakes, irreversibility, uncertainty, relational heterogeneity, or concentration of power can increase the relevance of independent review, model plurality, participation, monitoring, explicit exit conditions, and responsibility documentation. The orientation remains defeasible because procedural burden can itself create harm, delay, exclusion, or administrative lock-in.

Proportionality should also apply to formalization. A small decision can be obscured by an elaborate model whose data requirements exceed its practical value. A high-stakes decision can be underserved by a simple heuristic merely because it is easy to implement. The appropriate resolution of method should be justified in relation to the consequences and uncertainty of the practical commitment.

11.6.11 Defeasibility and Conflict among Orientations

Candidate orientations can conflict in ways that cannot always be resolved by a common metric. Broad participation can conflict with emergency speed. Transparency can conflict with privacy or security. Reversibility can conflict with the investment required to generate long-term capacity. Distributed authority can conflict with responsibility clarity. Robustness across futures can conflict with optimization for a strongly supported near-term scenario.

The existence of conflict does not imply that the framework should remain silent. It implies that practical judgment should identify the conflict, the positions affected, the evidence supporting each concern, the normative sources that give the orientations standing, and the consequences of prioritizing one over another. Some conflicts can be resolved through design; others can remain genuinely political, legal, ethical, or institutional.

A GR meta-framework should therefore resist transforming candidate orientations into a hidden utility function. Their role is to widen and discipline practical attention. Where a legitimate authority or normative theory establishes a priority, the decision process can incorporate that priority explicitly. Where priority remains contested, the contest should remain visible in the decision record.

11.6.12 Methodological Emergence and Open Research Problems

The methods discussed in Chapter 11 are examples of methodological forms currently available to the research programme. They do not exhaust the methods that a future GR or GRE practice may require. New practical fields can generate new forms of evidence, agency, coordination, participation, computation, and intervention. Existing methods can also be transformed through their interaction with one another.

A particularly important open problem concerns methodological emergence: how a practical field should generate, select, combine, and revise the methods through which it is known and governed. The present chapter offers situation mapping, candidate orientations, model plurality, historical interpretation, participatory method, intervention design, monitoring, and recursive revision as resources for this problem. It does not yet provide a complete theory of method composition under turbulence, deep uncertainty, high stakes, contested values, and changing power relations.

The same humility applies to the candidate orientations in this section. Value co-creation, relational viability, reversibility, option preservation, responsibility retention, power review, and epistemic plurality can each be useful under some conditions. None is asserted here as the invariant good of GR. Their relevance should be argued from the practical configuration and from whatever normative sources legitimately govern the decision.

Proposition 11.89 (Open methodological repertoire). *Application-dominant GR praxis can treat its methodological repertoire as historically revisable: situation categories, methods, evaluative considerations, and candidate practical orientations may be retained, modified, combined, or replaced when changes in evidence, agency, institutions, technology, relations, or normative understanding make alternative methodological forms more adequate to the practical field.*

Proposition 11.89 is a proposal about the status of the methodology rather than a claim that methodological change is always beneficial. Revision itself can introduce error, instability, or opportunistic manipulation. Methodological changes should therefore remain traceable and open to critical evaluation.

Sections 11.7 onward develop concrete families of decision and intervention method. They should be read in light of the two preceding sections: the methods form a repertoire whose relevance depends on the situation profile, and their practical use can be guided by candidate orientations without being mechanically determined by them.

11.7 Decision Analysis in Evolving Action Spaces

Section 11.4 established an epistemic architecture in which observation, interpretation, recognition, and evidence can update representations and can also become performatively coupled to transformations of an evolving relational field. Sections 11.5 and 11.6 then provided an open map of practical–epistemic situations and an illustrative repertoire of considerations and candidate orientations that can shape methodological composition. The role of the present section is to translate this meta-methodological preparation into decision analysis. Its objective is to develop a decision methodology that can compare and organize practical commitments while the relevant subjects, available actions, consequence structures, models, and future possibilities can themselves change through time. The discussion proceeds through ten movements: decision situations; historical-relational subjects; the status and provenance of actions; consequence and history structures; decision criteria; multi-criteria comparison; uncertainty and deep uncertainty; sequential and order-sensitive decision; collective decision; and revision of the action space. The method is formal-architectural and plural. It permits scalar optimization, probabilistic choice, qualitative comparison, partial ordering, historical interpretation, participatory judgment, and other decision procedures where their assumptions fit the practical problem.

Decision analysis in this setting begins from a different object than a fixed menu of alternatives. A practical decision situation is historically produced. Earlier actions, institutional rules, epistemic events, classifications, material transformations, and relations among subjects can determine which options are presently reachable, which remain latent, which have become expensive or illegitimate, and which have disappeared. The decision method therefore analyzes both choice among presently reachable actions and the generative structure through which the action space itself has been formed.

The same point applies to consequences. An action need not map to one terminal outcome. It can initiate, constrain, or reweight a family of later histories, while its implementation can alter the actors, institutions, criteria, and evidential conditions that later decisions inherit. A decision procedure that compresses these effects into one expected score can remain useful in a sufficiently stabilized problem, but such compression becomes a methodological choice whose information loss and normative assumptions should be explicit.

Table 11.7: Decision analysis in evolving action spaces

Component	Analytical object	Decision question	Characteristic methodological concern
Decision situation	Historically situated configuration, horizon, actors, and practical commitments	What exactly requires decision at this stage?	Boundary, timing, provenance, and changing field conditions
Historical-relational subjects	Subjects represented through histories, relations, capacities, roles, and internal structure	Who acts, who is affected, and how can the decision transform the subject?	Point-agent simplification, category change, relational dependence
Action-space status	Available, latent, and foreclosed actions with generative provenance	Which actions are reachable now, activatable later, or already lost?	Formal possibility versus effective reachability
History structure	Action-conditioned families of later histories	What trajectories can follow from each commitment?	Branching, path dependence, spillovers, future decision spaces
Decision criteria	Criteria applied to processes, histories, and consequences	Which dimensions matter for comparison?	Criterion fit, protected values, temporal and relational scope
Multi-criteria comparison	Partial, conditional, or aggregated comparison among actions	Which comparisons are warranted under plural values?	Incommensurability, priorities, dominance, unresolved remainder
Uncertainty	Probabilistic, structural, model, historical, implementation, and normative uncertainty	Which comparisons remain supportable under incomplete knowledge?	Deep uncertainty, model disagreement, evidential insufficiency
Sequential decision	Ordered sequences of actions and epistemic events	How does order change reachable histories and later options?	Noncommuting transformations, lock-in, learning, staged commitment
Collective decision	Distributed knowledge, authority, voice, and implementation capacity	How is a decision constituted across multiple subjects and institutions?	Representation, veto, delegation, burden, dissent, accountability
Action-space revision	Transformation of practical possibility through action and epistemic events	How should the decision frame change when options are generated or foreclosed?	Versioning, provenance, reopening, recoupling with inquiry

Table 11.7 summarizes the decision architecture developed in this section.

The architecture in Table 11.7 makes decision analysis recursive. A decision is evaluated partly by the histories it can generate, yet the decision process and the resulting action can also transform the domain over which later decisions are made. The method must therefore preserve enough structure to reconstruct how the decision frame changed, why certain alternatives became reachable, and which possibilities were lost.

11.7.1 Decision Situations

A decision method requires a local object of analysis. The broader practical situation reconstructed in Section 267 can contain many problems, actors, time horizons, and possible commitments. A decision situation selects the part of that field for which practical closure is presently being organized. The selection is analytical and institutional at once: it identifies what is to be decided, by whom, under which authority, over which horizon, and with what relation to later revision.

Definition 11.90 (Evolving decision situation). An *evolving decision situation* is a stage-indexed practical configuration in which one or more responsible positions must organize a commitment among presently relevant possibilities while the represented subjects, action space, evidence, criteria, and consequence structure can continue to change.

Definition 11.90 treats the decision situation as stage-indexed because the same practical problem can generate several materially different decisions through time. An early stage may concern whether to investigate further. A later stage may concern a pilot, authorization, scale-up, maintenance, redesign, suspension, or withdrawal. The identity of the decision should therefore be specified through its commitment object and temporal location rather than inferred from the continuing name of the project or institution.

For bookkeeping, a model can represent the decision situation at stage t through the tuple in Equation 11.1.

$$\mathfrak{D}_t = (\omega_t, \mathbf{S}_t, \mathcal{A}_t, \mathbf{C}_t, \mathbf{U}_t, \mathcal{I}_t, H_t). \quad (11.1)$$

In Equation 11.1, ω_t denotes the represented practical configuration; $\mathbf{S}_t$ the relevant subject and institutional positions; $\mathcal{A}_t$ the represented action space; $\mathbf{C}_t$ the criterion architecture inherited from Section 11.3; $\mathbf{U}_t$ the uncertainty structure; $\mathcal{I}_t$ the authority, responsibility, participation, and implementation arrangement; and H_t the relevant decision horizon. The tuple is a model-specific representation rather than a universal ontology. Historical narrative, institutional process maps, participatory records, qualitative case reconstruction, or other forms can perform the same analytical function without being translated into Equation 11.1.

The decision horizon deserves explicit treatment. A short horizon can make temporary stabilization appear attractive while hiding maintenance burdens or later option foreclosure. A long horizon can highlight delayed consequences while increasing uncertainty and model dependence. The method should therefore record both the horizon used for the immediate decision and any longer horizon over which relevant consequences are expected to emerge.

Definition 11.91 (Decision horizon profile). A *decision horizon profile* records the temporal interval over which the present commitment is authorized, the intervals over which material consequences are assessed, the expected timing of new information or review, and any horizon beyond which uncertainty is treated qualitatively or through alternative representations.

Decision situations also have provenance. The practical object may have been framed through an earlier diagnosis, inherited from a legal mandate, generated by an emergency, produced by a prior intervention, or reconstructed after failure. These origins matter because they influence which alternatives appear legitimate and which questions remain outside the frame. A decision method should therefore preserve a decision-situation record linking the present frame to its preceding problem formulation, diagnosis, goals, criteria, and epistemic events.

A decision situation can itself be performative. Publicly defining a decision as imminent can alter expectations, mobilize opposition, accelerate investment, delay cooperation, or induce actors to reposition before the formal decision occurs. The analytical frame can therefore become one of the events changing ω_t . Where this effect is plausible, the decision record should distinguish the configuration reconstructed before announcement from the configuration observed after the decision process became socially active.

Proposition 11.92 (Decision-situation provenance). *A decision analysis remains reconstructable when the decision object, horizon, practical boundary, responsible positions, inherited criteria, and major epistemic or institutional events that produced the present frame are recorded together with the alternatives considered within that frame.*

The subject positions represented within $\mathfrak{D}_t$ require further specification. The following subsection develops them as historical-relational objects whose practical capacities and identities can themselves change through decision and intervention.

11.7.2 Historical-Relational Subjects

Decision analysis often gains tractability by representing actors as points endowed with preferences, beliefs, resources, or utility functions. Such representations remain legitimate when their simplifications fit the practical question. The GR architecture developed earlier in the book also permits a richer representation in which the subject is historically extended and relationally constituted. This representation becomes especially useful when the decision changes the subject's capacities, institutional standing, internal organization, or relations to other subjects.

Definition 11.93 (Historical-relational decision subject). *A historical-relational decision subject is a decision-relevant representation of a subject that preserves the earlier events, internal organization, external relations, capacities, constraints, roles, and category assignments materially relevant to the present commitment.*

The representation can be narrative, tabular, graph-based, dynamical, agent-based, partially ordered, or higher-order. Where event history and internal relational organization are central, a labeled 2-complex can provide one convenient computational model. Vertices can represent selected event tokens, edges local relations or gluing conditions, faces higher-order compositions, and labels roles, capacities, categories, or provenance. The representation is selected for analytical usefulness; it does not imply that subjects possess a unique underlying 2-complex ontology.

A historical-relational subject has a boundary that can itself be disputed. An organization may be represented as a legal entity, a set of employees, an infrastructure and its users, a chain of contractors, or a field of relations extending beyond the formal organization. A household, community, professional group, or algorithmically mediated collective can similarly have several decision-relevant boundaries. The appropriate boundary depends on the mechanism, responsibility, and consequence under study.

Definition 11.94 (Subject-boundary profile). *A subject-boundary profile records the practical boundary used to represent a subject, the internal and external relations retained by that representation, the excluded relations judged less relevant at the current stage, and the conditions under which the boundary should be revised.*

This structure matters for preference and criterion analysis. A preference recorded at one time can be a product of earlier constraints, institutional classifications, learned expectations, or unavailable alternatives. Decision analysis can still use the expressed preference, yet its interpretation changes when the subject's historical formation is analytically relevant. The method can distinguish current

preference, protected interest, capability, role obligation, and potential future preference rather than compressing them into one stable ordering.

Subjects can also change through epistemic events. Recognition can create standing. Classification can alter eligibility. A forecast can change expectations. A diagnostic label can modify self-understanding or institutional treatment. An AI recommendation can redistribute interpretive authority. In these cases, the subject at stage $t + 1$ is not merely the same subject with one updated belief; the practical relations constituting the subject may have changed.

Definition 11.95 (Subject transformation record). A *subject transformation record* documents a material change in the represented subject's roles, capacities, constraints, relations, category status, internal organization, or practical identity that occurs during the decision process or as a consequence of earlier action.

The same discipline applies to collective subjects. A committee, institution, coalition, or community can develop capabilities and internal relations through the process of deliberation itself. Collective decision therefore cannot always be reconstructed as aggregation over a fixed set of pre-existing individual preferences. Section 11.7.9 returns to this issue after the action and consequence structures have been specified.

Proposition 11.96 (Subject-sensitive decision analysis). *When a contemplated decision can materially alter the capacities, relations, standing, or internal organization of affected subjects, the decision analysis should treat those transformations as part of the consequence structure rather than holding the subject representation fixed by construction.*

Historical-relational subjects act within action spaces that also carry histories. The next subsection distinguishes present reachability from latency and foreclosure while recording how particular actions entered the practical field.

11.7.3 Available, Latent, Generated, and Foreclosed Actions

An evolving decision analysis requires more than a list of candidate actions. Actions differ in present reachability, activation conditions, institutional legitimacy, temporal availability, reversibility, and generative provenance. The action space should therefore preserve both a current status and a history of how an option became possible or impossible.

Definition 11.97 (Decision-relevant action space). A *decision-relevant action space* is the stage-indexed representation of practical actions whose current reachability, activation pathways, constraints, provenance, and potential foreclosure are sufficiently relevant to the present decision to warrant explicit analysis.

Three current-status classes are especially useful. An *available action* is presently reachable under the operative authority, resources, capacities, and timing conditions. A *latent action* is not presently reachable but possesses a plausible activation pathway through learning, coordination, authorization, resource mobilization, institutional change, or capability development. A *foreclosed action* has lost effective reachability under the present history because a relevant window has closed, a required capacity has disappeared, a commitment has become irreversible, an institution has prohib-

ited the action, or the material configuration has changed.

Generation describes a different property. It records how an action entered the practical field. An action can be generated by earlier learning, coordination, infrastructure, legal reform, technological innovation, recognition of a new actor, creation of a collective capability, or reorganization of the problem itself. A generated action can subsequently become available, remain latent, or later become foreclosed. Treating generation as provenance prevents the analytical mistake of forcing it into the same status axis as current reachability.

Definition 11.98 (Action-status and provenance profile). An *action-status and provenance profile* records for a decision-relevant action its present reachability status, activation requirements, historical source, authority and capacity conditions, temporal window, dependencies, and known pathways through which it could become available, latent, or foreclosed at a later stage.

Formal permission provides only one component of reachability. An action can be legally permitted while practically unavailable because the actor lacks financing, information, coordination partners, institutional competence, time, or credible protection against retaliation. Conversely, an institution can possess substantial practical capacity for an action whose formal authorization is ambiguous. Decision analysis should therefore distinguish nominal possibility from effective reachability, continuing the action-space architecture developed in Section 271.

Latent actions are especially important under uncertainty. Additional inquiry can reveal a latent mechanism, but learning is only one activation route. Participation can generate collective capacity; sequencing can create infrastructure; a temporary intervention can preserve a later option; an institutional reform can make coordination possible; and a change in representation can make a previously invisible action intelligible. Decision analysis should therefore consider actions that can be generated by the process itself where such generation is materially plausible.

Foreclosure also requires provenance. The fact that an action is absent from the present menu does not establish that it was never possible. Earlier delay, investment, institutional commitment, environmental degradation, contractual lock-in, or loss of trust can remove an option. A decision record that preserves these losses can reveal path dependence and can prevent later analysis from treating the surviving menu as historically natural.

Definition 11.99 (Action-space omission risk). *Action-space omission risk* is the practical risk that a decision analysis excludes a materially relevant available, latent, generatable, or recently foreclosed action because the analytical frame treats the current visible menu as exhaustive.

Action generation can also create harmful possibilities. New infrastructure, authority, information, or coordination can expand capacities for coercion, extraction, exclusion, or irreversible transformation. Expansion of the action space therefore remains a descriptive change until evaluated through the criteria, justice architecture, and responsibility relations applicable to the situation.

Proposition 11.100 (Action-space status discipline). *A decision analysis in an evolving field should distinguish current action status from action provenance and should record materially plausible activation and foreclosure pathways when these pathways*

can alter the comparison among present commitments.

The decision value of an action depends partly on the histories it can initiate or prevent. The following subsection therefore replaces a single terminal-outcome representation with an action-conditioned consequence and history structure.

11.7.4 Consequence and History Structure

A practical commitment can produce immediate outcomes, delayed effects, institutional adaptation, feedback, subject transformation, and changes in future option spaces. Decision analysis should preserve enough of this temporal structure to distinguish actions whose short-run results appear similar but whose later histories differ substantially.

Definition 11.101 (Action-conditioned history family). For a represented decision situation at stage t , an *action-conditioned history family* is the model-specific set of admissible later histories associated with a contemplated action, including the branches generated by relevant implementation variation, environmental change, actor response, and subsequent epistemic events.

A formal model can denote this family by $\mathcal{H}_t(a)$ for action $a \in \mathcal{A}_t$. Where the model supports comparative weights, Equation 11.2 records a model-indexed history weight.

$$W_t^{(m)}(h \mid a, \mathfrak{D}_t), \quad h \in \mathcal{H}_t^{(m)}(a). \quad (11.2)$$

In Equation 11.2, m identifies the model or representation under which the history family and its weights are constructed. The quantity $W_t^{(m)}$ can represent probability, transition propensity, accessibility, plausibility, simulation frequency, or another explicitly defined quantity. The notation does not require probabilistic semantics. It also permits different models to generate different history families rather than merely different weights over one common set.

The consequence structure extends beyond terminal states. A history can contain changes in material conditions, relations, capacities, institutions, evidence, expectations, categories, responsibility, distribution, and future action spaces. Decision criteria can therefore be applied to a path, a transition, a temporal region, or a transformation of generative capacity rather than only to an endpoint.

Definition 11.102 (Generative consequence profile). A *generative consequence profile* records the materially relevant changes that a contemplated action can induce in immediate outcomes, relations, capacities, constraints, institutions, subject positions, epistemic conditions, and later action spaces across the relevant history family.

This profile is especially important when an action creates infrastructure or institutions that alter later possibilities. A policy, technology, organizational reform, or emergency measure can produce an immediate effect while simultaneously changing who can act, what can be observed, which categories become institutionalized, and which later interventions remain feasible. These secondary transformations belong to the decision object when they are materially relevant, even if the primary goal concerns a narrower outcome.

History families can also merge. Distinct initial actions can converge toward similar later configurations; conversely, a common early action can branch sharply under different implementation conditions. Scenario construction in Section 290 will develop these structures in detail. The present section uses them only to establish the object on which decision comparison operates.

A counterfactual comparison should preserve this history structure. The relevant alternative to action a may be another action, waiting, continuation of an existing arrangement, withdrawal, or a sequence whose first step is additional inquiry. The baseline is therefore a practical history family rather than a featureless condition of “no action.”

Definition 11.103 (Decision counterhistory). A *decision counterhistory* is an explicitly represented alternative history or history family used to compare a contemplated commitment with another reachable or analytically relevant pathway, including continuation, waiting, or withdrawal where these are practical possibilities.

Proposition 11.104 (History-structured consequence analysis). *When materially relevant effects unfold through path dependence, feedback, subject transformation, or changing action spaces, decision comparison should preserve those history structures to the extent required by the practical claim instead of relying solely on terminal-outcome summaries.*

The consequence and history structure supplies the object to which decision criteria are applied. The next subsection specifies that relation without assuming that every criterion can be reduced to the same numerical scale.

11.7.5 Decision Criteria

Section 11.3 distinguished goals, criteria, and thresholds. Decision analysis now applies that architecture to contemplated actions and their history families. The central methodological requirement is criterion-object fit: a criterion should evaluate the practical feature it was designed to represent at the temporal and relational scale on which that feature exists.

Definition 11.105 (Decision criterion application). A *decision criterion application* specifies how an evaluation criterion is applied to an action, process, history, history family, or transformation of practical possibility, together with the temporal horizon, affected positions, evidence basis, and comparison rule required for interpretation.

A safety criterion may apply to worst-case exposure during implementation. A participation criterion may apply to the process by which the action is authorized. A generative-opportunity criterion may apply to the future capabilities left to affected positions. A fiscal or material-resource criterion may apply to cumulative use over a horizon. A recognition criterion may require qualitative interpretation. These examples show why one action can have several decision-relevant representations without any one representation being treated as the complete consequence.

Criteria also differ in practical status. Some operate as protected constraints: alternatives failing them become inadmissible under the current practical architecture. Others support comparison among admissible actions. Some function as monitoring or revision triggers after commitment. The same substantive dimension can occupy

different roles at different stages, so the method should record whether a criterion is constitutive, protective, comparative, diagnostic, or adaptive in the present decision.

Definition 11.106 (Criterion-role profile). A *criterion-role profile* records the practical function of each criterion within a decision analysis, including whether it defines admissibility, comparison, priority, monitoring, escalation, revision, or reopening.

Decision criteria can also be history-sensitive. A criterion concerning autonomy may evaluate whether an action increases dependence over time. A criterion concerning reversibility may evaluate the evolution of rollback capacity. A criterion concerning institutional capability may distinguish a temporary surge from durable capacity. A criterion concerning justice may evaluate changes in the distribution of risk and generative opportunity rather than only immediate benefit.

Where a quantitative representation is useful, a criterion can be written as a model-specific functional $C_k^{(m)}$ applied to the relevant object. The notation in Equation 11.3 illustrates this possibility.

$$C_k^{(m)} : (a, \mathcal{H}_t^{(m)}(a), \mathfrak{D}_t) \mapsto Y_k^{(m)}. \quad (11.3)$$

Equation 11.3 leaves the codomain $Y_k^{(m)}$ open. It may be numerical, ordinal, categorical, interval-valued, set-valued, or structured qualitative output. This prevents the notation from silently requiring numerical commensurability.

Criterion evaluation can itself be uncertain. An action can be clearly superior on one dimension, poorly known on another, and incomparable on a third. The decision record should preserve this structure instead of filling every cell with an artificial number. Missingness, model disagreement, and qualitative uncertainty can be represented explicitly and can affect whether deeper commitment is supportable.

Proposition 11.107 (Criterion-object fit). A *decision criterion* is *methodologically informative* when its *practical role*, *object of application*, *temporal horizon*, *affected positions*, *evidence basis*, and *uncertainty* are specified at a level appropriate to the substantive dimension it represents.

With criterion applications established, the next methodological problem is comparison across several criteria whose relations can include reinforcement, priority, conditional trade-off, and incommensurability.

11.7.6 Multi-Criteria Decision

Practical decisions commonly involve several criteria that cannot be assumed to lie on one metric scale. Multi-criteria decision analysis in the present framework therefore begins with the criterion architecture from Section 11.3 and asks what form of comparison is warranted by the relations among those criteria.

Definition 11.108 (Multi-criteria comparison architecture). A *multi-criteria comparison architecture* specifies the admissibility conditions, criterion relations, priority rules, permissible conversions or weights, unresolved conflicts, and comparison procedures used to compare contemplated actions across heterogeneous practical dimensions.

Several forms of comparison are available. Dominance can identify an action that

performs at least as well across the relevant criteria under the adopted representation and better on at least one dimension. Priority rules can protect criteria judged constitutive or safety-critical. Lexical or staged procedures can evaluate protected constraints before comparative criteria. Partial orderings can leave some pairs unresolved. Aggregation can be used where commensurability and weighting have sufficient warrant. Deliberative or interpretive judgment can remain explicit where the practical object resists stable numerical conversion.

A useful first stage is admissibility filtering. Let $\mathcal{A}_t^{\text{reach}}$ denote the presently reachable actions and let $\mathbf{P}_t$ denote the protected criterion conditions. Equation 11.4 defines the corresponding admissible set schematically.

$$\mathcal{A}_t^{\text{adm}} = \left\{ a \in \mathcal{A}_t^{\text{reach}} \mid a \text{ satisfies the protected conditions in } \mathbf{P}_t \right\}. \quad (11.4)$$

Equation 11.4 does not determine a preferred action. It identifies which presently reachable actions remain eligible for further comparison under the current protected conditions. Those conditions can themselves be contested and revisable, so their provenance should remain visible.

Weighting requires particular care. A numerical weight can represent relative importance, a conversion coefficient, a negotiated priority, or a model-specific sensitivity parameter. These meanings should not be conflated. Where weights are used, the method should record their provenance and examine whether the recommendation changes materially across plausible weighting structures.

Definition 11.109 (Decision comparison remainder). *A decision comparison remainder is a materially relevant value, uncertainty, disagreement, loss, or consequence that remains unresolved or insufficiently represented after the adopted multi-criteria comparison procedure has been applied.*

The comparison remainder prevents apparent technical completeness from erasing unresolved practical material. A decision can still close provisionally, but the unresolved remainder should travel with the closure record and can become a monitoring or reopening object.

Multi-criteria analysis can also change the action space. A comparison may reveal that every currently available action performs poorly because the original design space is too narrow. The appropriate methodological response can then be option generation, institutional redesign, sequencing, or renewed inquiry rather than forced selection of the least unsatisfactory visible alternative.

Proposition 11.110 (Plural comparison discipline). *A multi-criteria decision procedure remains aligned with heterogeneous practical values when it uses only the conversions and aggregations supported by the criterion architecture, preserves protected conditions and unresolved remainders, and permits the comparison process to trigger revision of the action space where the existing alternatives are inadequate.*

The remaining uncertainty around actions, histories, criteria, and models can exceed the structure supported by ordinary probabilistic analysis. The next subsection distinguishes uncertainty from deep uncertainty and specifies how decision analysis can proceed without manufacturing precision.

11.7.7 Decision under Uncertainty and Deep Uncertainty

Decision analysis under uncertainty can take many forms. A probability distribution can be informative when the event space, model, parameterization, and empirical basis support probabilistic interpretation. Other situations involve uncertainty about the model itself, the relevant histories, the categories used to describe outcomes, future institutional response, implementation capability, or the values that later actors will apply. These forms require a broader architecture.

Definition 11.111 (Decision uncertainty profile). A *decision uncertainty profile* records the materially relevant uncertainty associated with the practical configuration, action status, consequence and history structure, criterion application, model choice, implementation process, affected positions, and future revisions of the decision frame.

Probabilistic uncertainty forms one part of this profile. Parameter ranges, confidence intervals, posterior distributions, simulation ensembles, or empirical frequencies can be useful where their semantics are warranted. Structural uncertainty concerns how the relations or mechanisms are represented. Model uncertainty concerns plausible alternative formalisms. Historical uncertainty concerns incomplete reconstruction of path dependence and earlier events. Implementation uncertainty concerns whether the contemplated intervention will be enacted as represented. Normative uncertainty concerns unresolved values, priorities, or standing.

Definition 11.112 (Deep practical uncertainty). *Deep practical uncertainty* is a condition in which one or more elements required for stable decision comparison—such as the model family, relevant history space, transition weights, consequence categories, implementation response, or criterion ordering—remain materially unsettled across reasonable representations or affected positions.

Deep uncertainty does not eliminate decision. It changes the appropriate form of analysis. The method can compare robustness across models, preserve several pathways, emphasize reversible commitments, use scenario families, impose protective constraints, expand monitoring, delay deeper commitment where learning is valuable, or authorize bounded protective action where waiting itself carries substantial consequence. Sections 292–292 develop these methods in greater detail.

The decision analyst should also distinguish uncertainty from disagreement. Two models can disagree because they encode different assumptions while both are precisely specified. Two affected groups can disagree about values while sharing the same factual model. A dataset can be sparse without there being any substantive disagreement. Preserving these distinctions helps identify whether the appropriate response is additional evidence, model comparison, deliberation, institutional negotiation, or action under acknowledged plurality.

A useful practice under deep uncertainty is to separate conclusions by stability. Some actions may remain admissible across a wide set of models and histories. Some may depend on one contested assumption. Some may be dominated only under a narrow probability assignment. The decision record can therefore report a stability profile instead of a single recommended ranking.

Definition 11.113 (Decision stability profile). A *decision stability profile* records which action comparisons, admissibility judgments, or practical conclusions per-

sist across the materially plausible models, history representations, uncertainty assumptions, and criterion structures considered in the analysis.

Epistemic sufficiency from Section 11.4 remains commitment-relative. Deep uncertainty can be compatible with a small reversible pilot and incompatible with a large irreversible commitment under the same evidence state. The decision method should therefore connect uncertainty to commitment depth instead of seeking one global confidence threshold.

Proposition 11.114 (Uncertainty-sensitive comparison). *When uncertainty concerns the model, history space, implementation structure, or criterion architecture itself, decision analysis should preserve that structural uncertainty in the comparison and evaluate the depth, reversibility, and learning architecture of the contemplated commitment accordingly.*

Decisions also occur in sequences. Because earlier commitments can transform the field and later action space, the order of actions and epistemic events can become analytically consequential.

11.7.8 Sequential and Order-Sensitive Decision

A sequence of individually reasonable actions can produce a different practical trajectory when their order changes. Early investment can create lock-in. Early participation can generate information and legitimacy that change later design. A temporary restriction can preserve time for learning. Premature standardization can foreclose experimentation. An epistemic event occurring before authorization can alter the set of actions considered, while the same information arriving after implementation may function only as a revision trigger.

Definition 11.115 (Decision pathway). *A decision pathway is an ordered sequence of practical commitments, epistemic events, observations, and review points whose composition changes the configuration inherited by later stages.*

Where state-changing transformations are represented by partial operators, order sensitivity can be expressed through composition. Equation 11.5 illustrates a case in which two admissible transformations have different compositions according to order.

$$\Phi_b \circ \Phi_a \neq \Phi_a \circ \Phi_b. \quad (11.5)$$

Equation 11.5 is a model-specific statement of noncommutativity. It can represent different final configurations, different intermediate exposures, different information states, or different domains of later admissibility. The same analytical point can be expressed without operator algebra through process tracing, event histories, institutional sequence analysis, or simulation.

Sequential decision therefore evaluates more than the set of actions eventually taken. It evaluates timing, precedence, staging, gates, feedback, and the conditions under which one step activates or forecloses another. A decision can be valuable because it preserves a later choice, generates information, builds capacity, or delays irreversible commitment until a specified observation becomes available.

Definition 11.116 (Sequencing value). *Sequencing value* is the practical value associated with the order of commitments because that order changes learning, exposure, capacity, coordination, reversibility, or the action space available at later stages.

Order-sensitive analysis also applies to criteria. A protected-rights screen applied before optimization can yield a different admissible set than a procedure that first maximizes an aggregate objective and evaluates rights only afterward. Similarly, problem definition before participation can differ from problem definition after participation. The order in which epistemic and normative operations are performed is therefore part of the method rather than a neutral procedural detail.

A sequential decision architecture should identify review gates. A gate can require a safety observation, participation milestone, capacity condition, financial limit, institutional authorization, or model update before the next commitment becomes available. Gates transform a one-shot decision into a contingent pathway and can preserve reversibility under uncertainty.

Definition 11.117 (Decision gate). A *decision gate* is a specified condition at which continuation, escalation, redesign, suspension, or reversal of a decision pathway is reconsidered using newly available evidence, consequences, capacities, or practical judgments.

Proposition 11.118 (Order-sensitive decision discipline). *When earlier commitments or epistemic events materially change later reachability, exposure, knowledge, or criteria, decision analysis should compare ordered pathways and gate structures in addition to comparing isolated actions.*

Sequential analysis becomes more complex when knowledge, authority, implementation, and exposure are distributed among several subjects. The next subsection treats collective decision as a relational architecture rather than a simple aggregation step.

11.7.9 Collective Decision

Collective decision arises when a practical commitment depends materially on several subjects or institutions whose knowledge, authority, values, implementation capacities, exposure, or rights differ. The collective object can be a committee, organization, partnership, public process, coalition, community, or distributed governance arrangement. Its decision architecture should reflect the relations through which a commitment becomes collectively authorized and enacted.

Definition 11.119 (Collective decision architecture). A *collective decision architecture* specifies the distribution of agenda-setting, evidence production, interpretation, proposal, participation, representation, authorization, veto, implementation, monitoring, review, and revision rights through which a collective practical commitment is constituted.

This architecture extends the participation and institutional analyses of Sections 276 and 279. Collective decision can use voting, consensus, delegated authority, negotiated agreement, professional judgment, participatory deliberation, algorithmically assisted recommendation, or hybrid arrangements. The methodological question concerns fit between the decision object and the rights, knowledge, respon-

sibilities, and affected positions organized by the chosen procedure.

Aggregation of individual preferences can be informative in some settings, but it does not exhaust collective decision. The process can generate new information, transform preferences, create shared categories, build trust, disclose hidden burdens, or produce a collective capability that was absent before deliberation. The collective subject after the decision process can therefore differ materially from the collection of positions represented at its beginning.

Definition 11.120 (Collective decision transformation). A *collective decision transformation* is a material change in shared knowledge, relational organization, trust, capability, standing, or practical orientation generated through the process by which a collective decision is formed.

Collective decisions also have asymmetrical burdens. Some participants provide technical analysis, others experiential knowledge, others implementation labor, and others bear the consequences. Time, language, confidentiality, digital access, organizational hierarchy, or economic dependence can affect whose participation becomes influential. A method that reports only formal voting rights can therefore miss the practical distribution of decision power.

Dissent should remain traceable. A decision can close under legitimate authority while preserving disagreement concerning evidence, values, risk, or expected consequences. The decision record should distinguish the authorized commitment from the distribution of reasons supporting or contesting it. This preserves material that can later become important in evaluation or reopening.

Collective decision can also distribute responsibility across interfaces. If one unit produces evidence, another authorizes action, a third implements, and a fourth monitors, failures can arise in the translations among them. The decision architecture should therefore map not only who holds each role but how information, authority, and responsibility travel between roles.

Definition 11.121 (Collective decision provenance record). A *collective decision provenance record* documents the participating and represented positions, decision rights, evidence and models considered, major disagreements, authorization pathway, implementation responsibilities, and review conditions through which a collective commitment was constituted.

Proposition 11.122 (Collective-decision traceability). A *collective decision remains accountable when the method preserves how distributed knowledge, voice, authority, dissent, implementation capacity, and responsibility were connected in producing the practical commitment.*

Collective decision does not end the evolution of the action space. The final subsection develops explicit revision of that space as a methodological operation.

11.7.10 Revision of the Action Space

The action space represented at the beginning of a decision analysis is provisional. Epistemic events, participation, negotiation, institutional change, implementation learning, material transformation, technological development, conflict, and earlier commitments can generate actions, activate latent actions, or foreclose previous

possibilities. Decision methodology should therefore include procedures for revising the action space itself.

Definition 11.123 (Action-space revision). *Action-space revision* is a documented change in the represented set, status, provenance, activation conditions, or dependencies of practical actions in response to materially relevant changes in knowledge, relations, capacities, constraints, institutions, or history.

A schematic update can be represented by Equation 11.6.

$$\mathcal{A}_{t+1} = \mathcal{G}_t(\mathcal{A}_t, \omega_t, e_t, a_t, \Delta \mathbf{S}_t, \Delta \mathcal{I}_t). \quad (11.6)$$

In Equation 11.6, e_t denotes a materially relevant epistemic event, a_t a practical commitment or action, $\Delta \mathbf{S}_t$ a change in subject configuration, and $\Delta \mathcal{I}_t$ a change in institutional or implementation conditions. The update operator $\mathcal{G}_t$ is representation-specific. A qualitative decision process can perform the same update through an option-generation workshop, participatory redesign, institutional review, historical reconstruction, or expert deliberation.

Revision can occur at several depths. A status revision changes an action from latent to available or from available to foreclosed. A parameter revision changes cost, scale, timing, or implementation conditions. A structural revision adds or removes an action family. A generative revision changes the mechanism through which further actions can be created. A boundary revision changes which actors or institutions are considered capable of action.

Definition 11.124 (Action-space version). An *action-space version* is a dated representation of the decision-relevant actions, their current statuses, activation pathways, provenance, dependencies, and known foreclosure conditions at a specified stage of practical analysis.

Versioning makes path dependence visible. If a later review considers only the current action space, it may interpret an earlier decision as irrational because an attractive option now exists that could not previously be reached. Conversely, an earlier choice can appear unavoidable if later records omit alternatives that were available at the time but were subsequently foreclosed. Action-space versions therefore complement the practical as-of state developed in Chapter 10.

Action-space revision also provides a safeguard against decision procedures that become trapped by their own original framing. If every available action violates a protected condition or performs poorly across the major criteria, the method can reopen diagnosis, search for latent options, generate new institutional combinations, or recouple the practical problem with research-dominant praxis. Forced selection from an inadequate menu is one possible procedural rule, but it is not a general requirement of decision analysis.

Definition 11.125 (Action-space reopening trigger). An *action-space reopening trigger* is a materially relevant development indicating that the current representation of practical possibilities is insufficient for responsible comparison, such as newly generated capacity, severe criterion failure across existing options, discovery of a foreclosed pathway, changed authority, or an epistemic event that alters the underlying practical configuration.

The action-space revision record should preserve why an option was added, activated, modified, or removed; which evidence or practical event motivated the change; which actors gained or lost practical possibilities; and how the revision affects earlier comparisons. This is especially important when institutions later evaluate whether an intervention expanded agency, produced lock-in, or redistributed the capacity to initiate further action.

Proposition 11.126 (Recursive decision analysis). *Decision analysis in an evolving practical field is recursive when it compares present commitments while remaining able to revise the represented subjects, action space, history structure, criteria, and uncertainty profile in response to materially relevant epistemic and practical events.*

The architecture developed in this section establishes the decision object for the next methodological step. A decision situation contains historical-relational subjects, evolving action spaces, action-conditioned history families, plural criteria, uncertainty, sequences, and collective decision structures. Section 290 develops generative history and scenario construction so that these future structures can be explored without presuming a single forecast or one fixed probability model.

11.8 Generative History and Scenario Construction

Section 11.7 established decision analysis over action spaces whose contents and reachability can change through practical and epistemic events. The present section develops the corresponding methodology for constructing possible continuations of a practical field. Its role is to replace a static catalogue of future states with structured families of histories that preserve path dependence, branching, merging, transformation of subjects and institutions, and revision of the action space itself. The objective is methodological rather than predictive: scenario construction organizes disciplined exploration of how present configurations may develop under specified actions, events, assumptions, and generative rules. The section proceeds through reference histories, alternative history families, counterfactual, adverse, transformative, and long-horizon histories, followed by branching and merging structures, history weights and transition potentials, model plurality, and scenario revision.

A scenario in this framework is not identified with a forecast. A forecast generally places greater emphasis on what is expected to occur under a specified model and evidence state. A scenario can instead be constructed to investigate possibility, mechanism, vulnerability, transformation, or decision sensitivity even when no defensible probability distribution over futures is available. Scenario construction therefore belongs especially naturally to application-dominant praxis under incomplete knowledge: it provides a disciplined way to compare pathways without claiming that the future has already been reduced to a stable probability space.

Definition 11.127 (Generative scenario). A *generative scenario* is a model-relative and revisable construction of one or more admissible histories generated from a specified practical configuration under stated actions, events, assumptions, transition structures, and boundary conditions, together with the provenance and uncertainty required to interpret those histories.

Table 11.8: Methodological architecture of generative history and scenario construction.

Component	Primary function	Characteristic discipline
Reference history	Establish a transparent comparison trajectory	Preserve assumptions and avoid treating the reference as destiny
Alternative families	Represent materially different continuations	Keep branching assumptions, mechanisms, and model provenance visible
Counterfactual history	Examine dependence on changed events or interventions	Preserve historical-relational coherence and downstream transformation
Adverse history	Stress-test vulnerability and protection	Explore consequential failure without requiring a single “worst case”
Transformative history	Represent changes in rules, subjects, and institutions	Permit structural and generative-rule change
Long-horizon history	Trace delayed and path-dependent consequence	Preserve option generation, foreclosure, maintenance, and inheritance
Branch/merge structure	Represent divergence and convergence of pathways	Distinguish temporal precedence from structural coupling
History weights	Express model-specific relative transition structure	State semantics explicitly and preserve non-probabilistic alternatives
Model plurality	Compare scenario constructions across formalisms	Preserve disagreement and avoid premature equivalence
Scenario revision	Update histories after epistemic or practical events	Version assumptions, branches, weights, and model changes

The word *generative* is important. A history can include changes in the subjects, relations, institutions, capacities, constraints, observation regimes, and practical rules through which later histories are themselves generated. A scenario method that holds all of these structures fixed may still be useful for a local question, but that simplification should be explicit rather than inherited silently.

Table 11.8 summarizes the methodological functions developed in this section.

11.8.1 Reference Histories

Scenario construction requires a comparison structure, yet the most familiar or institutionally established trajectory should not acquire privileged epistemic status merely because it has been labeled a baseline. A reference history is therefore defined by function: it provides a transparent trajectory against which alternatives can be compared. Its construction may use continuation of current arrangements, a policy-neutral convention, a central model trajectory, an historically recurrent pattern, or another explicitly justified rule.

Definition 11.128 (Reference history). A *reference history* is a stated model-relative continuation of the present practical configuration used as a comparison path for evaluating changes in actions, events, assumptions, mechanisms, or generative conditions.

The reference history should preserve its construction assumptions. If it assumes continuation of current institutions, that continuation is itself a substantive assump-

tion. If it assumes no new intervention, existing relations, infrastructures, degradation, learning, demographic change, technological development, or institutional adaptation can still generate substantial change. A “no new intervention” reference can therefore remain dynamically active.

Reference construction should also distinguish observational continuation from generative continuation. Extrapolating a measured trend can provide a useful observational reference. A generative reference additionally asks what mechanisms, relations, capacities, constraints, and institutional processes would have to persist for that trend to continue. The two can diverge when the observed pattern depends on conditions that are already changing.

Definition 11.129 (Reference-history provenance). *Reference-history provenance* records the model, data, historical window, continuation assumptions, institutional conditions, boundary choices, and uncertainty through which a reference history was constructed.

A reference history can also be plural. When current evidence supports several materially different continuations, a reference set may be more appropriate than one central trajectory. This avoids allowing an arbitrary “middle” scenario to become the tacit center of later evaluation.

The practical value of a reference history lies in comparison, diagnosis, and communication. It can reveal what an intervention changes, which mechanisms matter, and which consequences occur even in the absence of the focal action. Its value is weakened when the reference becomes an implicit forecast or a normative default.

Proposition 11.130 (Reference-history discipline). *A reference history should function as an explicit comparison construction whose assumptions and generative dependencies remain revisable; its use does not by itself establish that the represented continuation is the most probable, desirable, or institutionally appropriate future.*

Once a reference structure has been specified, scenario analysis can construct families of alternative continuations rather than isolated deviations around a single path.

11.8.2 Alternative History Families

An alternative scenario is often presented as a different endpoint or a small number of narrative pathways. GR requires a stronger representation when the pathway itself changes future possibility. Two histories can reach superficially similar states while differing in accumulated capacities, institutional memory, exposure, trust, legitimacy, or option spaces. Scenario construction should therefore preserve histories rather than only terminal outcomes.

For a practical configuration ω_t , model m , contemplated action or pathway a , and assumption set Θ , a model-specific family of admissible histories can be represented as Equation 11.7.

$$\mathcal{H}_t^{(m)}(a; \Theta) = \{h \mid h \text{ is admissible from } \omega_t \text{ under } (m, a, \Theta)\}. \quad (11.7)$$

Equation 11.7 is deliberately permissive. A history can be represented by a time-indexed state sequence, a partially ordered event structure, an agent-based

simulation trace, an institutional process narrative, a network evolution, a labeled 2-complex, or another locally justified representation. The set of admissible histories can be finite, continuous, generated procedurally, or analytically characterized rather than enumerated.

Definition 11.131 (Alternative history family). An *alternative history family* is a set of materially differentiated admissible continuations constructed to examine how changed actions, assumptions, events, relations, or generative rules can alter the practical trajectory.

Alternative families can be organized around different questions. One family may vary implementation quality while holding goals stable. Another may compare institutional arrangements. A third may explore different epistemic events, technological developments, ecological conditions, or forms of collective response. Scenario design should therefore state the dimension of variation and the structures held provisionally fixed.

An alternative family can also contain endogenous novelty. A history need not be generated by choosing one element from a fixed action list at each stage. Earlier events can generate new actions, new subjects, new institutions, and new observation capacities. The family can consequently expand as the simulated or reconstructed history evolves.

Definition 11.132 (Scenario-generating specification). A *scenario-generating specification* states the initial configuration, model or models, exogenous conditions, endogenous transformation rules, admissible actions, epistemic-event structure, boundary conditions, and stopping or horizon rules used to generate a history family.

The distinction between variation and novelty is methodologically useful. Parameter variation explores different values within a retained architecture. Structural variation alters relations or mechanisms. Generative variation permits the architecture that produces later possibilities to change. These levels can coexist within one scenario programme but should remain distinguishable in its records.

Alternative histories also support decision comparison from Section 11.7. An action can appear favorable in one narrow continuation and fragile across a broader history family. Scenario construction therefore prepares the more explicit robustness analysis of Section 291.

11.8.3 Counterfactual Histories

Counterfactual construction asks how a history could have differed under a changed event, action, relation, or condition. In a generative-relational framework, the changed element should be propagated through the downstream relational structure rather than inserted while every other feature is held artificially unchanged.

Definition 11.133 (Generative counterfactual history). A *generative counterfactual history* is a reconstructed or simulated continuation in which one or more antecedent conditions, events, actions, or relations are altered and the subsequent history is re-generated according to the model's stated dependency and transformation structure.

This definition places a discipline on counterfactual comparison. If an earlier institutional decision changes later capacity, authority, trust, or information, the counter-

factual should carry those changes forward where the model represents them. If an epistemic event changes the action space, the counterfactual cannot simply remove the event while preserving the later action menu that the event generated.

Counterfactual histories can serve several practical purposes. They can illuminate mechanism, estimate consequences under a causal model, reconstruct responsibility, examine path dependence, or evaluate whether an apparently necessary outcome depended on contingent earlier decisions. Their evidential standing varies accordingly. A formally identified causal counterfactual and an exploratory historical counterfactual can both be useful while making different warrant claims.

Definition 11.134 (Counterfactual dependency record). A *counterfactual dependency record* identifies which downstream relations, capacities, constraints, institutions, observations, and actions are permitted to change after the counterfactual antecedent is modified, together with the model or reasoning that governs those changes.

Historical-relational subjects require particular care. Removing one formative event from a subject's history may alter the later subject rather than merely alter one attribute of an otherwise fixed entity. A 2-complex or partially ordered representation makes this especially visible: modification of an earlier vertex, edge, or face can change which later extensions remain admissible.

Counterfactual analysis should also preserve uncertainty about historical uniqueness. Several counterfactual continuations may be compatible with the changed antecedent. A family of counterfactual histories can therefore be more faithful than one reconstructed alternative.

Caution 11.135 (Counterfactual inheritance). A counterfactual history should not inherit downstream structures from the observed history when those structures materially depend on the antecedent that has been changed. Preserving such structures can understate path dependence and create internally inconsistent comparisons.

Counterfactual analysis examines dependence on changed antecedents. Adverse histories shift the question toward vulnerability under consequentially unfavorable developments.

11.8.4 Adverse Histories

Adverse scenario construction explores histories in which materially important harms, failures, losses, or destabilizing conditions emerge. Its methodological role is to stress-test a decision or intervention architecture against consequential failure modes, including those that may be difficult to assign a stable probability.

Definition 11.136 (Adverse history). An *adverse history* is a scenario history constructed to examine materially harmful or practically unacceptable consequences, including their generative pathways, affected positions, propagation structure, detectability, containment, and possibilities for repair or reversal.

An adverse history is not necessarily the statistically least likely or numerically worst trajectory. Under deep uncertainty, such an ordering may not be defensible. Scenario design can instead select adverse histories because they expose a vulnerability, threshold, concentration of risk, correlated failure, institutional bottleneck, or irreversible loss.

Adverse histories can be generated through several routes: failure of a focal intervention, failure of an enabling institution, unfavorable external conditions, strategic response by other actors, observation or model error, cumulative maintenance failure, cascade across interdependent systems, or delayed consequences that become visible only after earlier options have been foreclosed.

Definition 11.137 (Adverse-pathway anatomy). An *adverse-pathway anatomy* records the initiating conditions, propagation mechanisms, amplifying relations, affected positions, warning signals, containment points, recovery capacities, and irreversible residues associated with an adverse history.

This anatomy helps distinguish protection from prediction. A decision can be designed against an adverse pathway even when the pathway lacks a precise probability estimate. Conversely, a low estimated probability does not automatically make a pathway practically negligible when exposure, irreversibility, concentration of burden, or failure of recovery capacity is substantial.

Adverse scenario construction should also include endogenous response. Institutions may learn, actors may adapt, affected subjects may resist, and emergency capacities may be activated. A scenario that freezes response can overstate damage; a scenario that assumes perfect adaptive response can understate vulnerability. The response structure should therefore be represented explicitly.

Proposition 11.138 (Adverse-scenario relevance). *The practical relevance of an adverse history depends on the consequence structure, exposure, propagation, reversibility, and response capacity represented in the scenario in addition to any model-specific estimate of frequency or probability.*

Adverse histories preserve existing practical architecture while stressing its failure modes. Transformative histories examine the stronger case in which the architecture itself changes.

11.8.5 Transformative Histories

Many practical scenarios treat future change as movement within a stable state space. GR also requires histories in which the relevant subjects, institutions, relations, categories, capacities, or generative rules change enough that the earlier representation becomes incomplete. These histories are especially important for structural intervention and long-horizon analysis.

Definition 11.139 (Transformative history). A *transformative history* is a scenario history in which materially relevant structures of practical generation—including subjects, relations, institutions, capacities, constraints, action spaces, observation regimes, or transition rules—undergo change that cannot be represented adequately as parameter variation within the initial practical architecture.

A transformative history can include institutional creation, dissolution, or reconstitution; formation of a collective subject; emergence of a new technology; ecological regime change; transformation of legal standing; development of a new epistemic infrastructure; or changes in the rules through which later options become admissible. Its defining feature is structural reconstitution, not magnitude alone.

Where a model represents practical evolution through a transition rule F_t , a trans-

formative history may require updating the rule itself. Equation 11.8 expresses one schematic possibility.

$$F_{t+1} = \mathcal{T}_t(F_t, \omega_t, e_t, a_t, \Delta \mathcal{I}_t). \quad (11.8)$$

Equation 11.8 states only that the later generative rule can depend on the prior rule, configuration, epistemic event, action, and institutional change. The representation can be implemented through dynamical systems, agent rules, operator families, graph rewriting, partial-order extensions, institutional process models, or other formalisms. The equation does not imply that one universal rule-update operator governs practical history.

Transformative scenarios should also address representation drift. Categories that were meaningful before the transformation may lose relevance afterward. Measures, criteria, and affected positions can change. A scenario system should therefore permit its observation and evaluation architecture to evolve with the represented field.

Definition 11.140 (Transformative discontinuity). A *transformative discontinuity* is a point or interval in a scenario history at which the prior representation, criterion structure, or generative rule becomes materially inadequate and requires explicit revision for later continuation.

Transformative histories are particularly useful when an intervention seeks to build capacity, create institutions, change dependency relations, or alter future option spaces. In such cases, evaluating only immediate outcomes can miss the principal object of intervention.

The methodological challenge becomes greater over long horizons, because delayed effects and changing representations accumulate across several generations of practical configuration.

11.8.6 Long-Horizon Histories

Long-horizon scenario construction extends practical analysis beyond the immediate decision cycle. Its central difficulty is not merely forecasting further into the future. The relevant relations, institutions, subjects, values, technologies, and observation systems may themselves change as the horizon extends.

Definition 11.141 (Long-horizon practical history). A *long-horizon practical history* is a scenario history constructed across a temporal span in which delayed consequences, maintenance, path dependence, institutional succession, option generation or foreclosure, and transformation of practical conditions become materially relevant to present judgment.

Long horizons require attention to temporal layering. Some effects appear rapidly while others accumulate slowly. A decision can create immediate benefit and long-run maintenance burden. Capacity can initially expand and later erode. A temporary institution can become entrenched. An intervention can preserve short-run stability while narrowing future generative opportunity.

Long-horizon analysis should therefore track inherited conditions. These can include infrastructure, debt, ecological state, organizational memory, standards, rights,

dependency structures, data archives, unresolved harm, and the action spaces left to later subjects. The object handed forward is a configuration rather than a scalar outcome.

Definition 11.142 (Inter-horizon carryover). *Inter-horizon carryover* is a condition, relation, capacity, constraint, institution, obligation, epistemic resource, or option-space transformation generated in one temporal horizon that materially shapes practical possibility in a later horizon.

Scenario construction can use nested horizons rather than one very long undifferentiated interval. Near-term histories may support detailed operational representation. Medium-horizon histories can emphasize institutional adaptation and capacity. Long-horizon histories may use broader structural variables, boundary conditions, and transformative branches. These representations can be linked without pretending that the same degree of precision is warranted across all horizons.

Long-horizon scenarios should also preserve future epistemic agency. Later subjects may possess knowledge, technologies, values, and institutional forms unavailable now. Present scenarios can model conditions for future revision rather than attempting to decide every later action in advance.

Proposition 11.143 (Long-horizon openness). *Long-horizon scenario construction should represent inherited constraints and generated possibilities while preserving explicit space for future epistemic events, institutional change, and practical revision whose content cannot be determined from the present evidence state.*

The histories considered so far can diverge and transform. The next subsection develops explicit branching and merging structures for representing these relations among histories.

11.8.7 Branching and Merging Structures

A set of independent scenario narratives can obscure shared prefixes, common bottlenecks, convergence, and recombination. Branching and merging structures make these relations explicit. Branching represents divergence after an event or decision. Merging represents later convergence of distinct histories into a shared configuration or equivalence class at the resolution relevant to the analysis.

Definition 11.144 (Scenario branching point). A *scenario branching point* is an event, decision, condition, or transformation after which two or more materially distinct admissible continuations are represented within the scenario architecture.

Definition 11.145 (Scenario merging point). A *scenario merging point* is a represented convergence at which histories with different earlier trajectories enter a common later configuration or become equivalent with respect to the distinctions retained by the model.

Merging requires interpretive care. Two histories can produce similar measured outputs while preserving different institutional memory, legitimacy, distributional consequence, or latent capacity. A merge should therefore be defined relative to an explicit equivalence criterion. Histories can merge for one decision problem and remain distinct for another.

Partially ordered event structures can represent concurrent developments without

forcing an artificial total chronology. A labeled 2-complex can provide a richer representation when vertices, edges, and faces encode events, relational couplings, and higher-order composed structures. In such a representation, branching corresponds to alternative admissible extensions, while merging can be represented through later attachments that join previously differentiated structures. This remains a computational choice rather than a claim that practical reality possesses one privileged combinatorial form.

Definition 11.146 (Branch–merge scenario graph). *A branch–merge scenario graph is a directed or partially ordered representation whose nodes or higher-order structures encode practical configurations or events and whose admissible extensions represent divergence, convergence, and recombination among scenario histories.*

Branching and merging also support decision gates. A reversible pilot can create several branches depending on observed effects. Several branches can later merge if different pathways produce sufficiently similar institutional or practical conditions. This structure makes explicit the option value of preserving multiple pathways before a later commitment.

A scenario method should record branch provenance: which action, epistemic event, assumption, or external condition generated the branch. Otherwise later users can see the alternative without knowing why it exists. The same principle applies to pruning. Removing a branch from active analysis should leave a record of the reason, evidence, and scope of the pruning decision.

The structural architecture of histories can be enriched further when the model supports relative weights or transition potentials among admissible continuations.

11.8.8 History Weights and Transition Potentials

Scenario construction does not require all admissible histories to have equal standing. Some models support a relative ordering, nonnegative weight, transition propensity, accessibility measure, simulation frequency, or probability over histories. Section 11.4 introduced this idea for epistemically mediated reweighting. The present subsection develops its use in scenario methodology.

Let $\mathcal{H}_t^{(m)}$ denote the admissible history family under model m . A nonnegative model-specific history-weight function can be written as Equation 11.9.

$$W_t^{(m)} : \mathcal{H}_t^{(m)} \longrightarrow \mathbb{R}_{\geq 0}. \quad (11.9)$$

Equation 11.9 does not determine the semantics of $W_t^{(m)}$. The model must state whether the value represents probability, plausibility, accessibility, transition propensity, empirical frequency, simulation mass, or another quantity. Normalization to one is appropriate only when probability semantics and the corresponding assumptions are justified.

A local transition-potential representation can instead attach a model-specific quantity to an admissible extension from configuration ω to ω' . Equation 11.10 gives a schematic form.

$$K_t^{(m)}(\omega' \mid \omega, e, a) \geq 0. \quad (11.10)$$

Equation 11.10 can encode local accessibility or transition propensity conditional on an epistemic event e and action a . Composition of local transition potentials into history weights depends on the chosen model. Markovian multiplication is one possibility, while path-dependent, non-Markovian, operator-valued, or simulation-based constructions may require different composition rules.

Definition 11.147 (History-weight semantics). *History-weight semantics* is the explicit interpretation assigned to a scenario weight or transition potential, including its domain, normalization properties, update rule, empirical relation, and admissible use in practical comparison.

Epistemic events can alter weights while preserving the history family, or they can change the family itself. An observation may increase the relative support for one mechanism. Institutional recognition may create a new branch. A new technology may generate histories absent from the earlier representation. Scenario revision should therefore distinguish *reweighting* from *history-space transformation*.

Amplitude-like constructions remain possible as a stronger modeling option. Such a model would require semantics for composition, phase, interference, observation, and empirical interpretation that go beyond the nonnegative weights in Equation 11.9. A 2-complex representation of history, including one inspired by spin-foam formalisms, does not by itself supply those semantics. Where amplitude-like quantities add analytical value and their interpretation is justified, they can be developed as a distinct model family rather than treated as the default scenario formalism.

Proposition 11.148 (Weight-interpretation discipline). *A scenario weight should be used in practical comparison only to the extent supported by its stated semantics, empirical relation, and update rule; numerical form alone does not justify probability interpretation or commensuration across models.*

Different scenario models can therefore produce different history spaces, branch structures, and weight semantics. The next subsection treats this plurality directly.

11.8.9 Scenario Model Plurality

Scenario construction can be carried out through historical narratives, participatory scenarios, causal models, dynamical systems, networks, agent-based simulations, formal transition systems, operator models, field models, partial-order event structures, 2-complexes, statistical ensembles, or hybrid architectures. These representations answer different questions and preserve different kinds of structure.

Definition 11.149 (Scenario model family). *A scenario model family* is a class of scenario constructions sharing a representation language, transition logic, evidential interface, and interpretation of histories while permitting variation in parameters, initial conditions, assumptions, or local structures.

Model plurality matters because scenario differences can arise from assumptions inside one model or from different models of the practical field. These sources of divergence should not be conflated. Parameter disagreement within a common

causal model differs from disagreement between a causal graph and an institutional-historical account about what structure is relevant.

Scenario comparison therefore requires a correspondence architecture rather than a presumption of equivalence. Models can sometimes be aligned around shared events, actors, constraints, outcomes, or decision-relevant questions even when their internal state spaces differ.

Definition 11.150 (Cross-model scenario correspondence). A *cross-model scenario correspondence* is a documented mapping between selected objects, events, consequences, or practical distinctions represented in different scenario models, used to support comparison without asserting identity between the models.

Convergence across models can strengthen confidence in a practical conclusion when the models are genuinely heterogeneous and share enough common object structure for the comparison to be meaningful. Divergence can be equally informative. It can identify hidden assumptions, boundary sensitivity, different historical reconstructions, or mechanisms that one representation cannot express.

A plural scenario programme should also preserve models that resist integration. Qualitative testimony about institutional fear, for example, may carry practical significance that a quantitative transition model cannot represent adequately. Conversely, a dynamical simulation can reveal feedback patterns difficult to infer from narrative evidence alone. Method combination can coordinate these insights while preserving their different epistemic functions.

Definition 11.151 (Scenario-model remainder). A *scenario-model remainder* is a materially relevant object, relation, uncertainty, value, or consequence represented in one scenario model that lacks a justified correspondence in another model used within the same practical analysis.

Scenario-model remainders should remain visible because apparently convergent conclusions may rest on omitted dimensions. They also identify priorities for future inquiry or method development.

Scenario construction is therefore a living methodological object. New evidence, practical events, or model failures can require revision of the histories themselves.

11.8.10 Scenario Revision

A scenario system constructed at time t can become inadequate as the practical field changes. New observations can alter transition weights. Epistemic events can create new branches. Implementation can transform subjects and institutions. A previously latent pathway can become available, while delay or irreversible commitment can foreclose another. Scenario revision provides the methodological machinery for preserving continuity while updating these structures.

Definition 11.152 (Scenario revision). *Scenario revision* is the documented modification of one or more reference histories, history families, branching structures, model assumptions, transition rules, weights, horizons, or represented objects in response to materially relevant epistemic or practical change.

Revision can occur at several levels. A *weight revision* changes relative support within a retained history family. A *branch revision* adds, removes, splits, or merges

scenario branches. A *structural revision* changes relations, mechanisms, or subject representation. A *rule revision* changes the generative logic that produces later histories. A *model revision* replaces or supplements the scenario model family itself.

These revisions should be versioned. A later scenario should not silently overwrite an earlier one, because earlier decisions may have been reasonable relative to the information and histories available at that time. Preserving versions supports responsibility, learning, and post-action re-epistemization.

Definition 11.153 (Scenario revision record). A *scenario revision record* documents the prior scenario version, triggering event or evidence, changed assumptions or structures, added or removed histories, weight changes, model changes, decision implications, responsible positions, and remaining uncertainty associated with a revision.

Revision also requires discipline against hindsight compression. Once one history has occurred, it can appear retrospectively inevitable. The scenario archive should preserve alternatives that were materially admissible earlier, including branches that later became foreclosed. This protects historical analysis from rewriting prior action spaces around the realized path.

Scenario revision can itself be performative. Publishing a new scenario may alter expectations, coordination, investment, institutional attention, or political feasibility and thereby change the future field represented by the scenario. The scenario system should therefore record materially important dissemination and uptake where these effects are plausible.

Proposition 11.154 (Revisable scenario architecture). *Scenario methodology should preserve a versioned relation among histories, assumptions, models, epistemic events, practical transformations, and decision implications so that later revision can change the scenario architecture without erasing the conditions under which earlier judgments were formed.*

Generative scenario construction therefore produces more than a set of possible futures. It produces an explicit architecture of reference, divergence, counterfactual dependence, adverse propagation, structural transformation, long-horizon carryover, branching and merging, weighted transition structure, model disagreement, and revision. The next methodological task is to ask which decisions remain supportable across these heterogeneous histories and representations. Section 291 develops that problem through robust decision-making across histories and models.

11.9 Robust Decision-Making across Histories and Models

Section 11.8 developed scenario construction as a disciplined exploration of reference, alternative, counterfactual, adverse, transformative, and long-horizon histories. The present section develops the decision methodology required when those histories remain multiple, when different models construct them differently, and when practical judgment must proceed without reducing uncertainty to one probability distribution. Its role is to specify robustness as a structured relation between contemplated commitments and the ranges of histories, models, values, scales, and historical trajectories across which those commitments remain practically support-

able. The objective is neither to identify one universally optimal action nor to privilege conservative choice. It is to determine where support for a practical commitment persists, where it becomes conditional, and where the decision depends materially on assumptions that remain contestable. The section proceeds through robustness, satisficing, minimax and regret, multiple models, multiple history representations, deep uncertainty, robustness across values, robustness across scales, and robustness across historical trajectories.

Robustness in this framework is therefore plural and indexed. A decision can be robust with respect to one source of variation and fragile with respect to another. An intervention can perform acceptably across many model specifications while depending on one disputed value priority. A strategy can be stable at the organizational scale while transferring vulnerability to another institution or population. A short-run policy can remain effective across many immediate histories while progressively foreclosing future options. Methodologically responsible robust decision-making should preserve these differences rather than compress them prematurely into a single robustness score.

Definition 11.155 (Robust practical support). *Robust practical support* is the persistence of sufficient practical warrant for a contemplated commitment across a stated range of materially relevant variations in histories, models, assumptions, values, scales, or historical conditions, together with an explicit account of the dimensions across which that support weakens, fails, or remains unresolved.

The term *sufficient* refers back to the commitment-relative architecture of Section 11.4. Robustness does not erase uncertainty. It asks whether a commitment remains supportable while uncertainty is represented in several materially plausible ways.

Table 11.9 summarizes the methodological architecture developed in this section.

11.9.1 Robustness

Robustness is meaningful only relative to a stated domain of variation. The phrase “robust option” is incomplete when the analyst does not specify what is being varied, which properties are expected to remain stable, what counts as acceptable performance, and over which temporal and relational horizons the comparison is made. The same action can be robust to parameter variation while fragile to institutional change, robust to one model family while fragile to another, or robust in aggregate while imposing severe losses on a particular affected position.

Let $\mathcal{D}$ denote a model-specific family of decision contexts. A context $d \in \mathcal{D}$ can index a model, assumption set, history family, value configuration, scale, temporal horizon, or another relevant combination. Let $A(a, d)$ denote whether action a remains practically acceptable in context d according to the applicable criterion architecture. The robustness-support set of a can then be represented as Equation 11.11.

$$\mathcal{R}(a) = \{d \in \mathcal{D} \mid A(a, d) = 1\}. \quad (11.11)$$

Equation 11.11 is intentionally modest. It does not require a scalar robustness score, a probability distribution over contexts, or identical outcome spaces across

Table 11.9: Methodological architecture of robust decision-making across histories and models.

Component	Primary function	Characteristic discipline
Robustness	Test persistence of practical support	State the domain of variation and preserve fragility
Satisficing	Identify acceptable rather than uniquely optimal options	Use explicit adequacy and protection conditions
Minimax/regret	Examine adverse performance under defined losses	Restrict use to justified comparison structures
Multiple models	Compare support across model families	Preserve model disagreement and model-specific semantics
History representations	Compare pathways across different history formalisms	Use correspondence without asserting representational equivalence
Deep uncertainty	Act when model, history, or criterion structure is unstable	Favor bounded commitment, learning, and reversibility where appropriate
Values	Test support across plural value configurations	Preserve protected values, partial orders, and unresolved remainders
Scales	Examine cross-scale stability and burden transfer	Distinguish local robustness from systemic robustness
Historical trajectories	Test support across path-dependent development	Evaluate option preservation, lock-in, and generative consequence

models. The acceptability relation can itself be composite and may include protected constraints, qualitative judgments, partial orderings, or model-specific requirements. Where acceptability is graded rather than binary, the same architecture can be represented through a richer codomain.

Definition 11.156 (Robustness domain). A *robustness domain* is the explicitly specified family of models, histories, assumptions, value configurations, scales, temporal horizons, and other materially relevant variations across which the support for a contemplated commitment is examined.

A robustness analysis therefore begins with boundary discipline. Excluding a plausible institutional failure, an affected subject, a long horizon, or an alternative model can create apparent robustness by construction. Conversely, including implausible or irrelevant perturbations can make every action appear fragile. The robustness domain should be justified by the practical diagnosis, evidence architecture, scenario construction, and consequences of error.

The analysis should also distinguish *performance robustness* from *structural robustness*. Performance robustness concerns whether relevant goals or criteria remain acceptably satisfied. Structural robustness concerns whether the action remains implementable, governable, monitorable, revisable, and institutionally coherent when the practical field changes. An intervention whose numerical outcome is stable but whose implementation requires one brittle institution may have high performance robustness and low structural robustness.

Definition 11.157 (Robustness profile). A *robustness profile* records the dimensions

across which practical support persists, weakens, becomes conditional, or fails, together with the assumptions, histories, models, values, scales, and temporal horizons associated with those changes.

This profile should preserve fragility. A decision process gains little by reporting that an option is “robust overall” if one particular failure mode dominates the consequences. Robustness is therefore best treated as a structured map of stability and sensitivity rather than a rhetorical label attached to a favored option.

Proposition 11.158 (Robustness-boundary discipline). *A claim of robust practical support is warranted only relative to an explicit robustness domain and an explicit criterion of persistence; changing either can change the robustness judgment without any contradiction in the underlying analysis.*

One consequence is that robust decision-making often seeks a region of acceptable commitments rather than a uniquely best point. The next subsection develops this satisficing orientation.

11.9.2 Satisficing

When values are plural, models disagree, and histories remain open, a decision methodology can often justify an *acceptable region* more credibly than a unique optimum. Satisficing in this section refers to the identification of actions or pathways that satisfy the relevant adequacy, protection, feasibility, legitimacy, and revision conditions at a level sufficient for the contemplated commitment.

Definition 11.159 (Satisficing region). *A satisficing region is the set of contemplated actions or pathways that satisfy the applicable protected conditions and meet the specified adequacy requirements within a stated robustness domain.*

Let $\mathcal{A}_t^{\text{reach}}$ denote the effectively reachable action space from Section 11.7, and let $\mathcal{C}$ denote a collection of admissibility and adequacy conditions. A schematic satisficing region can be written as Equation 11.12.

$$\mathcal{A}_t^{\text{sat}}(\mathcal{D}) = \left\{ a \in \mathcal{A}_t^{\text{reach}} \mid a \text{ satisfies } \mathcal{C} \text{ across the required portion of } \mathcal{D} \right\}. \quad (11.12)$$

The phrase “required portion” in Equation 11.12 is deliberately open. Some protected conditions may be required across the entire robustness domain. Other criteria may permit bounded exceptions, context-specific adaptation, or conditional branches. A high-consequence irreversible commitment can appropriately demand a stronger form of cross-context acceptability than a reversible trial.

Satisficing should not be interpreted as accepting mediocrity. Its methodological function is to prevent unsupported precision. If several options satisfy the relevant protected and adequacy conditions and the evidence does not warrant a unique ranking among them, declaring one option “best” can add apparent decisiveness without adding knowledge.

Satisficing can also support plural practical values. One criterion can set a safety floor, another a participation condition, another an implementation requirement, and another a minimum capacity-preservation condition. Some of these require-

ments may be noncompensatory. Superior performance on one dimension does not automatically license violation of another.

Definition 11.160 (Protected satisficing condition). *A protected satisficing condition is an adequacy or admissibility requirement that cannot be offset within the current decision architecture merely by superior performance on another criterion.*

The resulting decision problem can remain underdetermined after satisficing. That is methodologically acceptable. The remaining choice can be resolved through deliberation, sequence design, option preservation, randomization where appropriate, local judgment, or further inquiry. The key requirement is that the method disclose where the evidence and criteria cease to determine the choice.

Satisficing also interacts with action-space generation. When no current option enters the satisficing region, the appropriate response need not be selection of the least inadequate existing option. It may be to generate a new action, alter a constraint, build capacity, redesign the institution, or sequence several partial actions. Robust decision-making therefore retains the generative action-space logic of Section 11.7.

Proposition 11.161 (Generative satisficing). *Failure of all currently reachable options to satisfy the protected practical conditions can constitute a reason to expand or transform the action space rather than a reason to select the highest-ranked unacceptable option.*

Satisficing provides one way to avoid unsupported optimization. Minimax and regret methods provide another family of tools, particularly when adverse performance can be represented coherently.

11.9.3 Minimax and Regret

Minimax and regret constructions can be useful when the practical problem supports a sufficiently well-defined loss or performance relation across a stated uncertainty domain. Their strength is transparency about adverse cases. Their limitation is that the apparent rigor of a worst-case rule can conceal strong assumptions about what counts as loss, which contexts belong to the comparison domain, and whether the losses are commensurable.

Suppose that, for a particular local problem, a model-specific loss function $L_d(a)$ is justified for context $d \in \mathcal{D}$. A minimax action can be represented as Equation 11.13.

$$a^{\text{mm}} \in \arg \min_{a \in \mathcal{A}_t^{\text{adm}}} \sup_{d \in \mathcal{D}} L_d(a). \quad (11.13)$$

Equation 11.13 is appropriate only where the loss semantics and the robustness domain are defensible. It should not be treated as the default GR decision rule. A single extreme context can dominate the result, and that dominance may or may not be practically appropriate.

Regret shifts the comparison from absolute loss to the difference between the performance of an action and the best attainable performance within each context. When the relevant performance relation is numerical and comparable, context-specific regret can be represented as Equation 11.14.

$$\text{Reg}_d(a) = L_d(a) - \inf_{a' \in \mathcal{A}_t^{\text{adm}}} L_d(a'). \quad (11.14)$$

A minimax-regret rule then seeks an action with comparatively limited worst-case regret. This can be useful where decision-makers care about avoiding large ex post opportunity loss across plausible contexts.

Definition 11.162 (Regret interpretation record). *A regret interpretation record specifies the loss or performance relation, comparison set, uncertainty contexts, temporal horizon, affected positions, and assumptions through which a regret quantity acquires practical meaning.*

Both minimax and regret analysis can become misleading when a single scalar loss function erases value heterogeneity or distribution. A policy can have low aggregate regret while repeatedly assigning severe burdens to one group. Likewise, a minimax rule can become excessively conservative when the modeled worst case is structurally implausible or when avoiding it forecloses important future capability.

A GR-compatible use of these methods therefore treats them as *local lenses*. They can illuminate exposure to adverse contexts, but they remain embedded within a wider practical architecture containing protected values, distribution, reversibility, participation, responsibility, and action-space effects.

Proposition 11.163 (Local status of minimax and regret). *Minimax and regret methods can contribute to robust decision-making when their comparison domain and loss semantics are locally justified; their formal completeness does not by itself establish the completeness of the practical judgment.*

The need for local justification becomes stronger when several models organize the same practical problem differently.

11.9.4 Multiple Models

Model plurality is not merely a technical inconvenience to be removed before decision. Different models can preserve different mechanisms, timescales, actor structures, uncertainty forms, or institutional relations. Robust decision-making should therefore ask whether practical support survives across materially relevant model families and, where it does not, which modeling commitments generate the disagreement.

Definition 11.164 (Model-robust support). *Model-robust support is the persistence of practical support for a contemplated commitment across a stated family of models whose differences are materially relevant to the decision problem.*

A model family should not be constructed by superficial variation alone. Several parameterizations of one model architecture can provide useful sensitivity analysis, but they do not represent the same kind of pluralism as disagreement between, for example, a dynamical model, an institutional-historical reconstruction, and an agent-based model with endogenous adaptation.

For each model $m \in \mathcal{M}$, the analysis can produce a model-specific support relation $A_m(a)$, history family $\mathcal{H}^{(m)}(a)$, and uncertainty profile. The resulting comparison can be organized through a *model support matrix* rather than one aggregated score.

Definition 11.165 (Model support matrix). A *model support matrix* records, for each contemplated action and each materially relevant model, the applicable support judgment, principal assumptions, uncertainty, failure modes, and reasons for disagreement with other models.

Disagreement among models can have several sources. Models can differ in boundaries, state variables, actor representations, causal mechanisms, temporal resolution, endogenous adaptation, observation regimes, or criterion mappings. The robust-analysis task is therefore explanatory as well as comparative: the decision-maker should understand *why* model support differs.

Model disagreement can sometimes be resolved by evidence. In other cases, the models express alternative representations whose difference is not reducible to one missing parameter. Robust decision-making should preserve such unresolved plurality when the practical decision must nevertheless proceed.

A useful distinction is between *intersection robustness* and *conditional robustness*. Intersection robustness identifies options supported across the entire stated model family. Conditional robustness identifies options supported only under specified model classes or assumptions. The latter is not a failure of analysis; it reveals where the decision depends on unresolved modeling commitments.

Proposition 11.166 (Model-disagreement value). *Persistent disagreement across well-specified models can be practically informative because it identifies assumptions, mechanisms, boundaries, or representations on which the decision materially depends; robust analysis should therefore explain model disagreement rather than automatically average it away.*

Models can also disagree more fundamentally in how they represent history itself. The next subsection treats this representational plurality.

11.9.5 Multiple History Representations

Section 11.8 allowed histories to be represented as temporal trajectories, partially ordered event structures, institutional narratives, simulation traces, networks, labeled 2-complexes, or other forms. Robust decision-making should preserve this plurality because the same practical history can reveal different vulnerabilities depending on how temporal, relational, and higher-order structure is represented.

A time-series model can make cumulative change visible while suppressing event order beyond time index. A partial-order representation can preserve generative precedence without forcing unrelated events into one total sequence. A network history can reveal changing dependency structure. A 2-complex representation can preserve higher-order relational and historical composition. A narrative institutional reconstruction can preserve meaning, authority, and context difficult to encode in a compact state representation.

Definition 11.167 (Representation-robust support). *Representation-robust support* is the persistence of relevant practical support after the same decision problem has been reconstructed through several justified history representations that preserve materially different structures.

Cross-representation comparison requires a correspondence map or another trans-

lation discipline. Such a correspondence should identify which events, relations, outcomes, or criteria can be compared and which cannot. The absence of a justified translation is itself information.

Definition 11.168 (Robustness correspondence record). A *robustness correspondence record* documents the objects treated as comparable across history representations, the translation rule used, the information lost or added by that translation, and the practical claims that remain representation-dependent.

Robustness across representations does not mean that all representations should yield identical conclusions. A representation can disclose a path dependency or relational asymmetry that another omits. The analysis should distinguish contradiction from complementarity. Two representations can support the same action for different reasons, or they can disagree because one preserves a structure that the other intentionally abstracts away.

A practical decision becomes especially fragile when its support depends on a feature visible only in one narrow representation and disappears under several reasonable alternatives. Conversely, support that persists across representations with different failure modes can justify stronger confidence in the practical architecture, even when no single representation is treated as ontologically privileged.

Proposition 11.169 (Representational robustness). *Support that persists across several materially distinct and locally justified history representations can provide stronger practical warrant than support that depends on one representation alone, while remaining conditional on the adequacy of the correspondence used for comparison.*

When uncertainty concerns not only parameters or representations but the structure of the problem itself, robust decision-making enters the domain of deep uncertainty.

11.9.6 Deep Uncertainty

Deep uncertainty arises when the practical disagreement concerns the architecture used to describe the future, rather than only unknown values inside a stable model. The uncertain object can include the relevant model family, history space, transition structure, probability semantics, criterion ordering, action space, affected positions, or future generative rules.

Section 11.7 defined *deep practical uncertainty* as a condition in which elements required for stable decision comparison remain materially unsettled across reasonable representations or affected positions. The present subsection does not redefine that concept. It develops the corresponding robustness methodology by examining which practical commitments remain supportable while those structural uncertainties are preserved.

Definition 11.170 (Deep-uncertainty robustness profile). A *deep-uncertainty robustness profile* records how the practical support for a contemplated commitment changes across materially plausible variations in model structure, history space, transition semantics, criterion organization, action-space constitution, and future generative conditions.

Under deep uncertainty, assigning a precise distribution to all futures can produce false precision. Robust methods can instead organize several families of plausible structures and ask which commitments remain supportable across them. The output may be a bounded action, an adaptive pathway, an option-preserving intervention, a monitoring architecture, or a decision to generate additional capacity before deeper commitment.

A useful methodological object is a *deep-uncertainty ledger*. It records which elements are uncertain, whether the uncertainty concerns parameters or structure, what evidence could reduce it, what cannot currently be resolved, and which commitments are sensitive to it.

Definition 11.171 (Deep-uncertainty ledger). A *deep-uncertainty ledger* records structural and parametric uncertainties separately, identifies their practical consequences, and links them to monitoring, inquiry, adaptation, protection, and reopening conditions.

Deep uncertainty also makes the distinction between *robustness* and *rigidity* important. A rigid decision can perform acceptably under the modeled scenarios while lacking any capacity to respond when an unmodeled mechanism appears. A robust practical architecture often contains adaptive capacity, redundancy, diversity, slack, reversible commitment, or institutional learning precisely because the model space is incomplete.

This does not imply that deeper uncertainty always favors smaller or slower action. Urgent protective action can be warranted under deep uncertainty when delay itself creates severe exposure. The robust design question concerns the structure of commitment: scope, duration, reversibility, monitoring, escalation, de-escalation, and preservation of future options.

Proposition 11.172 (Deep-uncertainty response). *Under deep practical uncertainty, robust decision-making should evaluate the adaptability and learning capacity of the decision architecture itself in addition to the modeled performance of the initial action.*

This proposition prepares Section 292, but robustness must first be extended beyond epistemic variation to value plurality.

11.9.7 Robustness across Values

A decision can appear robust only because one value ordering has been fixed in advance. Section 11.3 established that practical goals and criteria can remain plural, partly ordered, and incompletely commensurable. Robust decision-making should therefore ask whether support for an action persists under materially plausible value configurations and where it depends on contested priorities.

Definition 11.173 (Value-robust support). *Value-robust support* is the persistence of practical acceptability across a stated family of value configurations, priority structures, protected conditions, or criterion interpretations relevant to the decision.

Value robustness does not require moral consensus. It can identify a set of actions that remain acceptable from several divergent value positions while preserving disagreement about the reasons for support. Such overlap can be practically important in collective decision-making because it permits coordinated action without pretend-

ing that the underlying normative disagreement has disappeared.

Where support diverges, the analysis should identify the decisive value dependency. One action may be preferred only when efficiency is assigned priority over reversibility. Another may remain acceptable only if a strong protection constraint is applied to one affected group. Another may depend on a particular intergenerational weighting. These dependencies belong in the robustness profile.

Robustness analysis should also preserve noncompensatory values. If a protected right, safety condition, or justice constraint is constitutive of practical acceptability, superior aggregate performance elsewhere should not automatically offset its violation. A value robustness procedure can therefore use partial orders, protected constraints, lexicographic priorities where justified, or sets of admissible value configurations rather than one weighted sum.

Definition 11.174 (Value-dependence frontier). A *value-dependence frontier* identifies the points at which the practical support for an action changes because a value priority, protected condition, criterion interpretation, or trade-off structure changes.

This frontier can be more informative than a single social objective function. It shows decision-makers and affected subjects which normative commitments are doing the work in the practical conclusion.

The analysis should also retain a *value remainder*: important values, losses, or disagreements that the robustness procedure does not represent adequately. Preserving such remainders is especially important when the decision will later be evaluated under a changed normative or institutional environment.

Proposition 11.175 (Value-plural robustness). A *practical commitment can possess robust support across plural values without those values being rendered commensurable, provided the comparison architecture makes protected conditions, value dependencies, unresolved conflicts, and revision conditions explicit.*

The same discipline is required across spatial, organizational, ecological, and social scales.

11.9.8 Robustness across Scales

A decision that appears robust at one scale can be fragile or harmful at another. An organizational intervention can stabilize local performance by transferring costs to front-line workers. A regional system can become more reliable by concentrating dependencies on one national infrastructure. A short supply chain can become resilient for one actor by displacing ecological or social exposure elsewhere. Robust decision-making therefore requires an explicitly multiscale analysis.

Definition 11.176 (Cross-scale robustness). *Cross-scale robustness* is the persistence of practically acceptable performance and consequence structure across the materially relevant scales at which an intervention acts, propagates, redistributes burdens, or changes future capacity.

Relevant scales can include individual, household, organizational, institutional, sectoral, regional, national, transnational, ecological, or other domain-specific levels. The set should be determined by the practical problem rather than fixed in advance.

Cross-scale analysis should distinguish *scale propagation* from *scale transfer*. Prop-

agation occurs when effects spread through connected levels. Transfer occurs when robustness at one level is achieved partly by moving risk, burden, maintenance cost, or fragility to another. An intervention can display local robustness and systemic fragility simultaneously.

Definition 11.177 (Robustness transfer). A *robustness transfer* occurs when improved stability, performance, or protection at one scale depends materially on increased exposure, fragility, burden, or reduced option space at another scale or position.

The analysis should also attend to timescale. Fast operational robustness can consume slow institutional capacity. A crisis response can be effective over days while degrading trust, maintenance capability, or ecological conditions over years. Multi-scale robustness therefore includes temporal scale as well as organizational or spatial scale.

A *scale-robustness matrix* can record the relevant criteria, affected positions, propagation pathways, and transferred burdens at each scale. Such a matrix need not force the scales onto one metric. Its function is to prevent local stability from being mistaken for system-wide robustness.

Proposition 11.178 (Cross-scale robustness discipline). A *claim of practical robustness* should specify the scale at which stability is observed and should examine whether that stability depends on burden transfer, hidden fragility, or capacity depletion at another materially connected scale.

Scale analysis remains incomplete, however, when it compares only contemporaneous configurations. Robustness should also be examined across different historical trajectories.

11.9.9 Robustness across Historical Trajectories

Robustness across historical trajectories asks whether a practical commitment remains supportable when the system arrives at similar present configurations through different histories or when the same initial action unfolds through different path-dependent sequences. This is especially important in GR because subjects, institutions, capacities, and option spaces carry historical structure. Present similarity does not guarantee equivalent future response.

Definition 11.179 (Trajectory robustness). *Trajectory robustness* is the persistence of practical support across materially different historical pathways, including differences in event order, institutional formation, accumulated capacity, memory, trust, burden, and option structure.

Two organizations can have the same current resource level while differing sharply in institutional memory and repair capacity. Two communities can show similar aggregate outcomes while carrying different histories of exposure, recognition, or trust. Two technological systems can provide the same present function while differing in lock-in, maintenance dependence, or future interoperability. A robust decision method should therefore avoid treating current-state equivalence as historical equivalence.

Trajectory robustness also concerns the action itself. A strategy can perform ac-

ceptably when introduced early but poorly when introduced after a sequence of prior commitments. Order-sensitive transformations from Section 11.7 therefore enter robustness analysis directly. If $\Phi_b \circ \Phi_a$ and $\Phi_a \circ \Phi_b$ generate different fields, support for a cannot be evaluated independently of its placement within the history.

A useful object is a *trajectory-robustness profile*, recording how support changes across alternative path structures, event orders, inherited capacities, and prior institutional states. This profile should include future action-space consequences. An option can be robust in immediate performance while repeatedly creating lock-in, narrowing future alternatives, or concentrating control over subsequent decisions.

Definition 11.180 (Generative robustness). *Generative robustness* is the capacity of a practical pathway to remain acceptably functional across materially plausible histories while preserving or regenerating the capabilities, relations, institutional conditions, epistemic access, and action spaces required for future adaptation and responsible revision.

Generative robustness is therefore stronger than repeated short-run performance. It asks whether the decision leaves the practical field capable of learning, adapting, repairing, contesting, and generating later alternatives. A pathway can be robust in outputs yet generatively brittle if it depends on irreversible concentration, opaque infrastructure, depleted capability, or loss of future epistemic agency.

This concept also clarifies the relation between robustness and resilience. The present chapter does not require a universal definition of resilience. Where resilience is used in a domain-specific methodology, it can be located within the broader generative robustness profile according to the capacities for absorption, recovery, adaptation, transformation, and future option generation that the particular model represents.

The section can now be summarized through a layered practical question. The analyst first asks whether an action remains acceptable across specified histories and models. The analysis then asks whether that support survives representational differences, deep uncertainty, plural values, connected scales, and path-dependent historical structures. Finally, it asks whether the pathway preserves the capacity to revise itself when those conditions change.

Proposition 11.181 (Generative robustness principle). *For application-dominant praxis under materially open futures, robust practical support is strongest when a commitment remains acceptable across relevant histories and models while also preserving sufficient capacity for monitoring, learning, adaptation, repair, contestation, and future action-space revision.*

This final condition creates the transition to adaptive decision-making. Robust analysis identifies the regions in which a commitment can remain supportable despite variation; Section 292 develops the methods by which the commitment itself can change as epistemic events, monitoring, action-generated evidence, and field transformation alter those regions through time.

11.10 Adaptive Decision-Making in Evolving Fields

Section 11.9 developed robustness as persistence of practical support across materially relevant variation in histories, models, values, scales, and historical trajectories. The present section addresses the complementary methodological problem that arises when the practical field itself changes while a decision pathway is underway. Its role is to develop adaptive decision-making for situations in which epistemic events, observation, intervention, institutional response, actor learning, and generated consequences can alter the configuration being governed, the models used to represent it, the relative weights of admissible histories, and the action space available for later choice. The objective is to specify conditional decisions, update conditions, monitoring effects, model and history-weight revision, adaptive pathways, reversible commitment, escalation, de-escalation, action-space regeneration, and the co-evolution of decision rules with the fields in which they operate. The method is intentionally plural: formal rules can be used where their semantics are justified, while qualitative, institutional, historical, and participatory updating remain equally available when the practical object cannot be adequately represented by one numerical state.

Adaptive decision-making in this framework is therefore more than repeated re-optimization. A decision procedure can alter after new observations, but the observation regime can also alter behavior; an intervention can reveal a mechanism while simultaneously changing that mechanism; a policy can generate new capacities or dependencies; and the decision rule itself can become part of the relational field that later actors learn, anticipate, resist, or exploit. Adaptation should consequently preserve a reconstructable distinction among changes in representation, changes in practical configuration, changes in the model family, changes in history weights, and changes in the decision rule.

Definition 11.182 (Adaptive decision architecture). An *adaptive decision architecture* is a versioned arrangement of conditional commitments, observation and update rules, monitoring responsibilities, revision pathways, reversibility provisions, escalation and de-escalation conditions, and action-space regeneration mechanisms through which practical decisions can change as materially relevant epistemic or practical events transform the represented field.

Table 11.10 summarizes the methodological architecture developed in this section.

11.10.1 Conditional Decisions

Adaptive decision-making begins by replacing unconditional one-shot commitment with explicit conditional structure where the practical situation supports it. A conditional decision specifies what commitment is authorized under a stated configuration, what observations or events matter for continuation, and what forms of revision become available when those conditions change. Conditionality can concern initiation, continuation, scale, duration, participation, resource release, monitoring intensity, or the depth of institutional change.

Definition 11.183 (Conditional practical decision). A *conditional practical decision* is a commitment whose authorization, continuation, modification, escalation, suspen-

Table 11.10: Methodological architecture of adaptive decision-making in evolving fields.

Component	Primary function	Characteristic discipline
Conditional decisions	Link commitments to specified practical conditions	Preserve the conditions, authority, and revision logic of each commitment
Epistemic events	Trigger reassessment when knowledge or recognition changes	Distinguish readout, interpretation, and performative transformation
Monitoring effects	Observe trajectories while tracking observation-induced change	Treat monitoring regimes as potentially constitutive of the field
Model and history updating	Revise representations and relative support for histories	Preserve update semantics, provenance, and structural uncertainty
Adaptive pathways	Organize contingent sequences of practical commitments	Specify branches, gates, fallback routes, and learning opportunities
Reversible commitment	Preserve feasible correction under uncertainty	Maintain rollback capacity, memory, resources, and authority
Escalation	Increase commitment when stated conditions warrant deeper action	Separate evidence, consequence, capacity, and authorization conditions
De-escalation	Reduce exposure or commitment when continuation loses support	Preserve repair, transition, and learning rather than treating retreat as failure
Action-space regeneration	Create or restore later practical possibilities	Track capabilities, institutions, relations, and option-generating interventions
Rule-field evolution	Revise decision rules as their own effects accumulate	Version rules and monitor performative, strategic, and institutional feedback

sion, reversal, or termination depends on explicitly stated practical conditions and on a specified procedure for determining whether those conditions obtain.

A simple model-specific representation can map a decision-relevant interpreted configuration to a set of permissible commitments. Let Z_t denote the representation used by the decision procedure at stage t , and let $\mathcal{C}_t$ denote the currently admissible commitment forms. A conditional decision rule can be written as Equation 11.15.

$$\delta_t : Z_t \rightarrow \mathcal{C}_t. \quad (11.15)$$

Equation 11.15 is a schematic rule rather than a claim that practical judgment reduces to a mathematical function. The map can be partial because some represented situations may fall outside the rule's warranted domain. The codomain can also contain composite commitments such as "continue at present scale with intensified monitoring," "pause expansion and investigate a newly observed mechanism," or "activate a protected fallback pathway." Qualitative deliberation and institutional authorization can therefore remain part of the rule's implementation.

The conditions attached to a decision should themselves be typed. An *epistemic con-*

dition concerns what is sufficiently understood. A *consequence condition* concerns observed or anticipated effects. A *capacity condition* concerns whether implementation, monitoring, repair, or reversal remains feasible. An *institutional condition* concerns mandate, authority, coordination, or accountability. A *justice condition* concerns burdens, benefits, risk, recognition, participation, or generative opportunity. A *temporal condition* concerns windows within which a commitment remains meaningful or reversible.

Definition 11.184 (Decision-condition profile). A *decision-condition profile* records the conditions that govern initiation, continuation, modification, escalation, de-escalation, suspension, reversal, or reopening of a practical commitment, together with the observation regime, responsible positions, and authority through which each condition is interpreted.

Conditional decisions should avoid pseudo-precision. A condition such as “continue if performance remains acceptable” is operationally weak unless the relevant performance dimensions, affected positions, uncertainty, and authority of interpretation are specified. Conversely, overly rigid numerical conditions can become brittle where measurement is noisy, performative, delayed, or incomplete. The appropriate form of conditionality depends on the practical object.

Conditional architecture also has distributive consequences. Actors with authority to interpret whether a condition has been met can acquire substantial practical power. An adaptive method should therefore record who defines the indicators, who observes them, whose testimony can trigger review, who can challenge the interpretation, and who bears the consequences of false continuation or false suspension.

The value of conditionality lies partly in its capacity to separate stages of commitment. A practical system can authorize an initial action while withholding deeper commitment until specified learning, capacity, safety, or participation conditions are met. This converts some uncertainty into a structured sequence rather than requiring either complete prior knowledge or unconditional action.

11.10.2 Epistemic Events as Update Conditions

Section 11.4 distinguished observation as readout from epistemic events that can acquire performative consequences through interpretation, communication, recognition, classification, or institutional uptake. Adaptive decision-making uses epistemic events as possible update conditions while retaining that distinction. A new measurement, testimony, anomaly, model comparison, classification change, or machine-generated pattern can justify revision of a decision rule, yet the event can also change the practical field once actors respond to it.

Definition 11.185 (Adaptive update condition). An *adaptive update condition* is an epistemic or practical event whose occurrence is specified as materially relevant to the continuation, revision, escalation, de-escalation, suspension, or reopening of a decision pathway.

Not every new observation should trigger revision. Continuous adaptation to weak signals can produce instability, strategic manipulation, or excessive administrative burden. Update conditions should therefore be connected to the practical signifi-

cance of the event, the reliability of the observation regime, the depth of current commitment, and the cost of both delayed and premature revision.

Epistemic events can operate at several levels. A *parameter-level event* changes an estimate within an otherwise stable representation. A *structural event* challenges the relations or mechanisms represented by the model. A *boundary event* reveals an affected subject, relation, scale, or consequence that had been omitted. A *normative event* changes the practical interpretation of values, responsibilities, or protected conditions. A *generative event* creates a new capacity, institution, relation, or action that changes the space of possible decisions.

An adaptive rule should record which level is implicated. Updating a parameter when the event actually challenges the model structure can create false continuity. Replacing the entire model after an ordinary parameter fluctuation can create unnecessary instability. The response should be proportionate to the type and practical significance of the epistemic event.

The event can also change the interpretation of earlier evidence. A newly identified mechanism may make an old observation newly relevant. Later testimony can reveal that an earlier aggregate indicator concealed concentrated harm. A new institutional category can reorganize historical records. Adaptive updating can therefore include *retrospective re-epistemization*, while preserving the as-of state that originally informed the decision.

Proposition 11.186 (Typed-update discipline). *When an epistemic event materially affects an adaptive decision pathway, the revision should distinguish whether the event changes a parameter, model structure, practical boundary, normative interpretation, generative condition, or some combination of these, because different update types warrant different practical responses.*

Epistemic events are often detected through monitoring. Monitoring, however, is itself part of the practical architecture and can alter the field it observes.

11.10.3 Monitoring and Observation Effects

Monitoring supports adaptation by producing repeated observations of implementation, consequences, capacities, risks, institutional response, and changes in the practical field. Yet monitoring should not be treated as an invisible window onto an unchanged system. Measurement can redirect attention, alter incentives, change reporting behavior, stabilize categories, create surveillance burdens, or influence the expectations of actors who know they are being observed.

Definition 11.187 (Monitoring regime). A *monitoring regime* is the organized arrangement of observations, indicators, reporting relations, interpretive procedures, responsibilities, temporal cadence, and revision pathways through which an adaptive decision process follows the evolution of a practical field.

The monitoring regime should identify both the *observation object* and the *observation effect*. The observation object is what the method seeks to learn about. The observation effect is the change generated because measurement, reporting, inspection, participation, publication, or classification occurred. The two can coexist. A monitoring system can reveal a deterioration in service quality while the publication

of that indicator simultaneously changes staff behavior and organizational priorities.

A useful methodological record is an *observation-effect profile*, which asks whether the monitoring regime changes incentives, trust, disclosure, participation, strategic behavior, resource allocation, or the categories through which the practical problem is understood. These effects may be beneficial, harmful, or mixed. Their presence does not invalidate monitoring; it makes performativity part of the method's consequence structure.

Monitoring also has a temporal architecture. High-frequency observation can detect rapid instability but can amplify noise and encourage short-horizon reaction. Low-frequency observation can preserve stability but miss fast deterioration or narrow windows for reversible intervention. Different variables can therefore require different cadences. Fast operational signals and slow institutional, ecological, relational, or capability indicators may need to coexist.

Adaptive monitoring should preserve epistemic pluralism. Quantitative indicators can be combined with qualitative observation, historical comparison, front-line reports, affected-subject testimony, expert judgment, and machine-assisted pattern detection. Their disagreement can itself be an update condition. A stable aggregate metric alongside persistent localized testimony, for example, can indicate a boundary problem, distributional masking, or measurement failure.

Monitoring burden also matters. Repeated reporting can consume scarce capacity, privilege actors able to produce standardized data, or shift labor toward what is measurable. An adaptive system that exhausts the institution it monitors can become self-defeating. Monitoring intensity should therefore remain proportionate to decision relevance, risk, reversibility, uncertainty, and available capacity.

The dedicated monitoring methodology developed later in Section 303 will examine indicator design, observational infrastructures, and monitoring governance in greater detail. The present section establishes the narrower adaptive point: monitoring both informs and participates in the evolution of the decision field.

11.10.4 Updating of Models and History Weights

Adaptive decision-making requires a disciplined account of what changes when new evidence arrives. Some events support parameter updating within an existing model. Others justify revision of model structure, replacement of a model family, modification of the represented history space, or reweighting of admissible histories. These operations should remain distinct enough that later users can reconstruct why the decision pathway changed.

Let $\mathcal{M}_t$ denote the active model family at stage t , and let W_t denote whatever model-specific history-weight structure is being used where such a structure is justified. An epistemic update can be represented schematically by Equation 11.16.

$$(\mathcal{M}_{t+1}, W_{t+1}) = \mathcal{U}_t^{\text{ep}}(\mathcal{M}_t, W_t; e_t, x_t, \rho_t), \quad (11.16)$$

where e_t denotes the epistemic event, x_t the associated readout or representation where applicable, and ρ_t a record of the assumptions, provenance, and practical context used in the update. Equation 11.16 deliberately leaves the update operator

open. Depending on the model, it can represent Bayesian conditioning, parameter estimation, qualitative reinterpretation, likelihood-free reweighting, model comparison, structural revision, replacement of a causal account, or another explicitly defined procedure.

The semantics of W_t remain model-specific. Where W_t is a probability distribution, normalization and probabilistic updating may be appropriate. Where it represents accessibility, plausibility, transition propensity, simulation mass, or another nonnegative quantity, probability language should not be imported automatically. Where no coherent weighting semantics exist, the adaptive method can revise scenario families qualitatively without inventing numerical weights.

A second distinction concerns *reweighting* and *history-space transformation*. An update can change the relative support attached to already represented histories. It can also create a new branch, remove an obsolete branch, reveal a previously omitted subject, or alter the generative rule through which future histories are constructed. In the latter case, the history space itself changes.

Definition 11.188 (Adaptive model revision record). An *adaptive model revision record* documents the epistemic event or practical consequence that triggered revision, the prior model and history representation, the update operation, changes in parameters or structure, changes in history weights or admissible histories, remaining model disagreement, and the resulting implications for practical commitment.

Model plurality should remain visible through updating. If several model families interpret the same epistemic event differently, adaptation can preserve the disagreement rather than forcing immediate convergence. The decision may remain robust across the models, become conditional on one interpretation, or require deeper inquiry before commitment is increased.

The possibility of amplitude-like history models remains open under the stronger assumptions specified in Section 11.8. Adaptive updating in such a model would require semantics for the update of amplitudes, phase relations, composition, and observation. The present general method therefore continues to use nonnegative history weights and transition potentials as the more permissive vocabulary where weighting is needed.

11.10.5 Adaptive Pathways

An adaptive pathway organizes conditional decisions through time. It specifies an initial commitment, anticipated observation points, branch conditions, possible expansions or contractions, fallback routes, and the practical conditions under which the pathway should be reconsidered. The pathway is therefore neither a fixed plan nor a sequence improvised without memory. It is a versioned structure for contingent commitment.

Definition 11.189 (Adaptive pathway). An *adaptive pathway* is a temporally and relationally ordered family of practical commitments connected by explicit branch, review, escalation, de-escalation, suspension, reversal, or regeneration conditions that can be revised as the represented field changes.

Adaptive pathways can take several forms. A staged pathway can move from re-

versible trial to limited deployment and then to broader commitment. A branching pathway can select different responses according to future conditions. A portfolio pathway can maintain several parallel options until uncertainty narrows. A protective pathway can authorize temporary safeguards while a deeper diagnosis proceeds. A recovery pathway can prioritize stabilization, repair, and later institutional redesign.

The pathway should record *branch provenance*. A branch should exist for an identifiable practical reason: a model uncertainty, safety concern, institutional dependency, distributional risk, learning opportunity, or value conflict. Excessive branching can make the pathway administratively unusable, while insufficient branching can hide materially different future conditions under one rule.

Adaptive pathways also have generative effects. An early stage can build capability, create trust, generate institutional memory, or develop new monitoring infrastructure. These effects can make later actions reachable. Conversely, an early commitment can create lock-in, exhaust capacity, or change expectations in ways that close later branches. Pathway design should therefore evaluate the action-space consequences of each stage as part of the decision itself.

A useful methodological object is a *pathway state record*, which at each review point preserves the current practical configuration, active branch, observed consequences, unresolved uncertainties, model versions, available actions, responsible positions, and next review conditions. This prevents adaptive decision-making from becoming a sequence of disconnected reactions whose original rationale cannot later be reconstructed.

Proposition 11.190 (Adaptive-pathway discipline). *An adaptive pathway is methodologically stronger when each major transition preserves a traceable relation among the triggering condition, the evidence and model state, the authority for revision, the action-space consequence, and the residual uncertainty carried forward.*

One important design property of an adaptive pathway is the preservation of reversible commitment.

11.10.6 Reversible Commitment

Reversible commitment permits action under incomplete knowledge while preserving feasible pathways for correction. The concept extends the practical reversibility developed in Chapter 10 into a methodological design principle. Reversibility requires more than a statement that a decision can later be changed. It requires sufficient material, institutional, informational, legal, and relational capacity to make reversal, repair, or redirection practically reachable.

Definition 11.191 (Reversible commitment architecture). *A reversible commitment architecture is the set of design provisions that preserve a practically usable pathway for suspending, redirecting, rolling back, repairing, or replacing a commitment within the relevant horizon and with burdens judged acceptable for the affected positions.*

A reversible architecture can include modular implementation, temporary authorization, staged resource release, preserved alternatives, data portability, contractual

exit clauses, institutional redundancy, fallback infrastructure, reserve capacity, repair funds, documentation, and protected authority to trigger rollback. Which elements matter depends on the domain.

Reversibility is also positional. An institution may be able to terminate a programme while affected subjects remain unable to restore lost housing, employment, trust, health, status, ecological conditions, or institutional standing. The method should therefore evaluate reversal across materially relevant positions rather than from the perspective of the formal decision-maker alone.

The architecture should also recognize *reversibility decay*. A commitment that is easy to reverse during an early stage can become difficult to undo after complementary investments, institutional adaptation, expectation formation, dependency, or loss of alternative capacity. Review intervals should therefore be related to the rate at which rollback capacity is expected to decline.

A useful concept is a *reversibility reserve*: the resources, authority, institutional memory, technical capacity, relational access, and practical options retained specifically to support later correction. Using that reserve for immediate performance can increase short-run efficiency while making adaptation more brittle. The trade-off should remain visible.

Reversible commitment is valuable partly because it can create learning while limiting exposure. Yet reversibility should not be used to justify careless experimentation. A formally reversible pilot can still impose concentrated burdens, alter trust, generate stigma, or create hard-to-repair relational effects. Reversibility modifies the commitment profile; it does not cancel the requirements of justice, participation, or responsibility.

11.10.7 Escalation

Escalation increases the depth, scale, duration, resource commitment, institutional reach, or irreversibility of a practical pathway. In an adaptive architecture, escalation should occur through explicit conditions rather than by inertia. Early implementation success can create political, organizational, or psychological momentum that makes expansion appear self-justifying. The method should preserve the distinction between evidence that the current stage is functioning and evidence sufficient for a deeper stage.

Definition 11.192 (Adaptive escalation). *Adaptive escalation* is an authorized increase in the depth, scale, duration, resource commitment, institutional reach, or practical irreversibility of a pathway following review of the conditions relevant to that increase.

Escalation conditions can include several dimensions. An *epistemic condition* concerns whether the mechanism and consequence structure are sufficiently understood for deeper commitment. A *performance condition* concerns whether relevant goals and criteria are being met. A *capacity condition* concerns whether the implementing system can absorb expansion without degrading quality, monitoring, repair, or accountability. A *distributional condition* concerns whether benefits, burdens, and risks remain acceptable across affected positions. A *reversibility condition* concerns

whether deeper commitment would create material option loss. An *authorization condition* concerns whether the institution has legitimate authority for the expanded action.

An *escalation gate* records these requirements and the evidence used to interpret them. The gate can be conjunctive, partially ordered, or deliberative. It does not need to collapse all conditions into a scalar score. Some protected conditions may function as noncompensatory constraints.

Escalation can also be asymmetric. Increasing scale can be easy while later reduction is politically or technically difficult. Increasing data collection can create infrastructures that persist after the original purpose ends. Expanding an institution's authority can change expectations and power relations even if the formal authorization remains temporary. The escalation review should therefore examine future de-escalation and exit at the moment deeper commitment is considered.

Proposition 11.193 (Escalation burden principle). *As a practical pathway increases exposure, duration, scale, irreversibility, option foreclosure, or institutional concentration, the methodological burden ordinarily shifts toward broader evidence, stronger consequence tracking, clearer responsibility, and more explicit justification of the remaining revision and exit pathways, subject to the urgency and consequence structure of the situation.*

Proposition 11.193 is deliberately scoped. Urgent protective action can justify rapid escalation under severe threat even when evidence remains incomplete. The deeper commitment should then carry intensified monitoring, review, and de-escalation provisions appropriate to that uncertainty.

11.10.8 De-Escalation

De-escalation reduces the depth, scale, duration, exposure, or institutional commitment of a practical pathway. It is an affirmative adaptive operation rather than simply a failure to continue. A pathway can require de-escalation because the intervention no longer produces sufficient benefit, because harms or inequities have emerged, because institutional capacity is being depleted, because a new model changes the expected history structure, because the problem itself has changed, or because a temporary protective measure has served its purpose.

Definition 11.194 (Adaptive de-escalation). *Adaptive de-escalation* is an authorized reduction, narrowing, suspension, transition, or staged withdrawal of practical commitment in response to materially relevant changes in evidence, consequences, capacity, values, authority, risk, or the practical field.

De-escalation requires design. Abrupt withdrawal can transfer burden to actors who adapted to the intervention, destroy useful capacity, or create a vacuum in maintenance and responsibility. A de-escalation pathway should therefore specify transition duties, preserved functions, repair, communication, reassignment of responsibility, and continued monitoring where delayed consequences remain possible.

The method should distinguish several forms. *Scope de-escalation* narrows the population, domain, or mechanism addressed. *Intensity de-escalation* reduces resource use or intervention strength. *Temporal de-escalation* shortens duration or reduces fre-

quency. *Institutional de-escalation* returns authority or responsibilities to other positions. *Epistemic de-escalation* reduces reliance on a model, indicator, or automated system whose warrant has weakened.

De-escalation can also preserve learning. A programme that contracts after detecting a failure mode can retain records, infrastructure, and experimental knowledge for later redesign. Treating de-escalation as institutional embarrassment can create incentives to conceal adverse evidence. Treating it as an expected part of adaptive governance can improve epistemic honesty and reduce lock-in.

A useful methodological object is a *de-escalation transition record*, documenting the trigger, affected functions, responsibilities transferred or retained, repair obligations, residual consequences, preserved knowledge, and conditions under which a redesigned pathway could later be reconsidered.

Escalation and de-escalation together prevent adaptation from being equated with unidirectional growth. A mature adaptive system can deepen, narrow, pause, redirect, or terminate commitments according to the evolving field.

11.10.9 Action-Space Regeneration

Adaptive decision-making is incomplete when it only chooses among currently reachable actions. Sections 11.7 and 11.8 showed that histories can generate and foreclose options. The present subsection turns that observation into an explicit methodological objective: when the current action space is inadequate, adaptation can seek to create, restore, or recombine practical possibilities.

Definition 11.195 (Action-space regeneration). *Action-space regeneration* is the deliberate creation, restoration, recombination, or reactivation of practical capacities, relations, institutions, knowledge, authority, infrastructures, or coordination pathways that make later actions newly reachable or recover previously foreclosed possibilities.

Regeneration can occur through capability development, institutional redesign, trust repair, new coordination mechanisms, resource mobilization, legal authorization, technological change, knowledge production, translation, conflict transformation, or restoration of damaged infrastructure. The relevant mechanism should be specified rather than described only as “expanding options.”

Action-space regeneration is especially important when the satisficing region from Section 11.9 is empty or when every currently reachable option violates an important protected condition. The adaptive problem then shifts from selecting an existing action to transforming the field so that a better action becomes possible.

A model-specific update of the effective action space can be represented as Equation 11.17.

$$\mathcal{A}_{t+1}^{\text{reach}} = \mathcal{G}_t(\mathcal{A}_t^{\text{reach}}, \omega_t, e_t, a_t, \Delta \mathbf{S}_t, \Delta \mathcal{I}_t, \Delta \mathbf{K}_t), \quad (11.17)$$

where $\Delta \mathbf{S}_t$ denotes changes in relevant subjects or relational positions, $\Delta \mathcal{I}_t$ institutional change, and $\Delta \mathbf{K}_t$ changes in practical capacities or knowledge. Equation 11.17 extends the recursive action-space architecture of Section 11.7 by emphasizing the

deliberate regeneration of reachability.

Regeneration should remain normatively assessed. Generating new power, information, surveillance capacity, coercive authority, or technical capability can create harmful actions as well as beneficial ones. The methodological question is therefore which possibilities are generated, for whom, under whose control, with what dependence, and with what consequences for later agency and justice.

A useful *regeneration profile* records the option-generating mechanism, beneficiaries, newly capable actors, dependencies, required maintenance, possible harmful capabilities, and the durability of the resulting action space. This makes option generation itself an evaluable intervention rather than an unexamined good.

Action-space regeneration also links adaptation to research. If the barrier is epistemic, new inquiry can generate a practical option. If the barrier is institutional, organizational redesign can create new authority or coordination. If the barrier is relational, participation or trust repair can make cooperation possible. Adaptive methodology should therefore identify what kind of generative transformation is required before assuming that more analysis of the existing menu will improve the decision.

11.10.10 Co-Evolution of Decision Rule and Field

The preceding subsections imply that an adaptive decision rule cannot always be treated as external to the field it governs. Conditional rules shape expectations. Monitoring changes behavior. Escalation and de-escalation alter institutions. Repeated criteria can stabilize categories. Automated rules can invite strategic response. Action-space regeneration changes who can act. Over time, the decision rule and the practical field can therefore co-evolve.

Definition 11.196 (Rule–field co-evolution). *Rule–field co-evolution* is the reciprocal historical process through which decision rules influence the practical configuration and the resulting changes in actors, relations, institutions, observations, capacities, and histories subsequently alter the appropriateness, interpretation, or structure of those rules.

A schematic representation can separate the field update from the rule update. Let ω_t denote the practical configuration and δ_t the operative decision rule. Their coupled evolution can be represented as Equation 11.18.

$$\begin{aligned}\omega_{t+1} &= \Phi_t(\omega_t; a_t, e_t, \delta_t), \\ \delta_{t+1} &= \mathcal{V}_t(\delta_t; \omega_{t+1}, e_t, \mathcal{M}_{t+1}, W_{t+1}).\end{aligned}\tag{11.18}$$

Equation 11.18 is a modeling template. The first line represents transformation of the practical field under action, epistemic events, and the institutional consequences of the rule itself. The second represents revision of the decision rule in response to the changed field and updated epistemic architecture. The functions Φ_t and $\mathcal{V}_t$ need not be numerical and need not remain fixed through time.

This co-evolution creates several methodological risks. A rule can become self-validating if it determines what gets measured and then treats those measurements as evidence of its success. Actors can learn to optimize against the rule, changing the relationship between indicator and underlying practical condition. An institution

can develop capabilities specialized to one decision architecture and thereby make alternatives harder to implement. Temporary categories can become durable identities or administrative boundaries. Adaptive governance should therefore monitor the consequences of the rule itself.

Definition 11.197 (Decision-rule provenance). *Decision-rule provenance* is the record of how a practical decision rule was formed, the evidence and models on which it depended, the conditions under which it was authorized, its successive revisions, the field changes associated with its operation, and the reasons for maintaining, replacing, or retiring it.

Versioning is central to this provenance. A rule that has changed repeatedly should not be treated as though it were one timeless method. Each version can carry a different action space, criterion architecture, model family, authority structure, and consequence profile. Versioned records permit later evaluation to distinguish failure of an original design from failure introduced through cumulative adaptation.

Co-evolution also means that successful adaptation can eventually make its original rule unnecessary. A temporary coordination mechanism can build durable institutional capacity. A safety intervention can transform conditions so that the original trigger rarely occurs. A participatory process can generate collective agency that supports a different governance architecture. Adaptive methodology should allow retirement or transformation of its own decision rule when the field it helped create no longer warrants the original structure.

Proposition 11.198 (Adaptive co-evolution principle). *In evolving practical fields, adaptive decision-making is strongest when it treats decision rules, observation regimes, models, action spaces, and institutional capacities as historically revisable components whose own effects can become objects of monitoring, evaluation, and redesign.*

The architecture developed in this section extends robust decision-making from comparative stability to governed change. Conditional decisions specify how commitment depends on the field; epistemic events and monitoring create update conditions; model and history structures remain revisable; adaptive pathways preserve staged alternatives; reversible commitments retain correction capacity; escalation and de-escalation govern changes in depth; action-space regeneration creates later possibilities; and rule-field co-evolution makes the decision procedure itself part of the object of inquiry. Section 293 turns next to optimization and its limits, examining where optimization can serve this broader adaptive architecture and where its assumptions become too restrictive for historically evolving, heterogeneous, and partially incommensurable practical fields.

11.11 Decision-Making under Critical-Transition Uncertainty

The role of this section is to develop a decision architecture for practical fields in which qualitative transition is a plausible possibility and the system's location relative to such a transition remains uncertain. Its objective is meta-methodological: it does not assume that every social, institutional, ecological, technological, or economic field

is near criticality, and it does not treat criticality as an ontological diagnosis available directly from observation. The section instead asks how decision discipline should change when one or more defensible models admit regime change, bifurcation, tipping behavior, abrupt reorganization, strong path dependence, or comparable transition structures within the practical horizon. The discussion proceeds through criticality as a model-relative hypothesis, regime uncertainty, response sensitivity, diagnostic evidence, intervention-induced transition, hysteresis and path dependence, staged commitment, multiscale monitoring, model plurality, and transition-sensitive decision discipline. The method combines dynamical-systems reasoning with the historically relational and epistemically plural architecture developed earlier in the chapter.

Dynamical-systems theory provides several formal languages for qualitative changes in system behavior, including bifurcation and changes in stability structure (Kuznetsov 2023; Strogatz 2024). Research on critical transitions also shows that some systems can exhibit conditional early-warning patterns before certain threshold changes, while the interpretation and reliability of such indicators remain model- and context-dependent (Scheffer et al. 2009). These literatures motivate a practical distinction between ordinary uncertainty within a relatively stable regime and uncertainty about whether the regime itself can change. The present section uses that distinction as an analytical resource under the book's ontological-suspension commitment.

Definition 11.199 (Critical-transition decision context). A *critical-transition decision context* is a practical situation in which one or more defensible representations admit a nearby or decision-relevant qualitative change in the system's dynamical, institutional, relational, or generative regime, while the location, mechanism, timing, or even existence of that transition remains uncertain enough to affect practical judgment.

The definition deliberately includes uncertainty about the criticality hypothesis itself. A field can display volatility, delay, polarization, rapid technological change, institutional stress, or nonlinear response without satisfying the assumptions of a particular critical-transition model. Decision methodology should therefore preserve the difference between observing unusual change and establishing that a formal criticality model applies.

Table 11.11 summarizes the main practical qualifications developed in this section.

The rows in Table 11.11 are qualifications rather than universal prescriptions. Some critical-transition models support precise quantitative analysis; other practical fields justify only a qualitative hypothesis that the response structure may be changing. The common methodological requirement is to avoid silently extending stable-regime inference into a region where the representation itself suggests possible structural change.

11.11.1 Criticality as a Model-Relative Practical Hypothesis

Criticality enters application-dominant praxis through a model or family of models. A dynamical representation can contain an equilibrium that loses stability, a basin boundary that moves, a threshold beyond which another attractor becomes accessi-

Table 11.11: Decision qualifications under critical-transition uncertainty.

Analytical issue	Ordinary local assumption	Critical-transition concern	Practical qualification
Response structure	Marginal response remains locally transportable	Response can change sharply across regimes	Preserve model plurality and local validity domains
Historical trajectories	Nearby starting points yield comparable histories	Small differences can enter qualitatively different histories	Examine branching, basin change, and path dependence
Evidence transport	Recent evidence remains informative for the next stage	Data can straddle or precede a regime change	Time-stamp evidence and reopen transport assumptions
Intervention effect	Action perturbs a stable field	Action can contribute to crossing a transition boundary	Stage commitment and monitor transition-sensitive signals
Reversibility	Removing an intervention approximately restores prior conditions	Hysteresis or generated structure can obstruct return	Preserve options, repair capacity, and post-transition monitoring
Monitoring	Stable indicators provide sufficient feedback	Aggregate or delayed indicators can miss local reorganization	Use multiscale, heterogeneous, and mechanism-sensitive monitoring
Decision rule	One calibrated rule remains applicable	Rule performance can be regime-dependent	Pre-specify revision and reauthorization conditions

ble, or a parameter region in which response becomes highly sensitive. An institutional or historical analysis can identify analogous reorganization without claiming mathematical identity with a physical phase transition. The methodological status of these representations should remain explicit.

Definition 11.200 (Criticality hypothesis). A *criticality hypothesis* is a scoped and revisable claim that the practical field may be located in a region where one or more represented transition mechanisms can produce a qualitative change in trajectories, stability, relational organization, or reachable future configurations.

The hypothesis has at least four components: a represented field or subsystem, a proposed transition mechanism, an evidential basis for locating the field relative to the transition, and a statement of practical consequences if the hypothesis is wrong or incomplete. Different models can propose different order parameters, boundaries, or transition mechanisms. A decision architecture should preserve those differences when they materially affect action.

This model-relative treatment avoids two opposite errors. One error is to dismiss nonlinear or transition-sensitive dynamics because the system cannot be described with the precision of a laboratory model. The other is to label any rapid or surprising

change as criticality. The middle position treats criticality as a hypothesis whose practical relevance depends on whether it changes what should be monitored, compared, staged, protected, or kept reversible.

11.11.2 Regime Uncertainty and Local Model Fragility

Many decision methods rely on local regularity. Recent observations are used to estimate response; causal relations are transported over a short horizon; marginal effects are extrapolated; or parameters are assumed to vary smoothly. These methods can remain useful near a transition, but their validity domain can become narrower when the system's governing relationships are changing.

Definition 11.201 (Regime uncertainty). *Regime uncertainty* is uncertainty concerning which qualitative response structure, stability pattern, institutional configuration, or generative mechanism currently governs the practical field and how that governing structure can change within the decision horizon.

Regime uncertainty differs from parameter uncertainty inside one fixed model. A confidence interval around a parameter does not automatically represent uncertainty about whether the model family remains appropriate after a qualitative transition. A decision process can therefore require both parameter uncertainty and model-structure uncertainty.

Local model fragility should be interpreted proportionately. A model can remain useful for short-horizon monitoring even when its long-horizon extrapolation becomes unreliable. A causal mechanism can remain valid for one subpopulation while the aggregate field reorganizes. A stable local control rule can remain safe within a bounded region. The practical question concerns the domain in which the model continues to carry enough of the field for the intended commitment.

11.11.3 Sensitivity, Amplification, and Divergent Histories

Critical-transition uncertainty increases the importance of history-space analysis. Near some represented boundaries, small differences in initial configuration, parameter path, event order, or intervention timing can contribute to markedly different later histories. The relevant decision problem can therefore concern the distribution of reachable regimes and the preservation of future options as much as the optimization of an expected local outcome.

The word *sensitivity* has several meanings and should be disambiguated. Numerical sensitivity concerns changes in model output under perturbed input. Dynamical sensitivity concerns divergence of trajectories under the model's evolution. Institutional sensitivity can concern whether a small procedural change activates a qualitatively different rule. Relational sensitivity can concern whether a change in one tie or position reorganizes a larger network. A practical analysis should state which sense is relevant.

Scenario families from Section 11.8 become especially important here. Reference histories can be supplemented with transition histories, failed-transition histories, delayed transitions, overshoot paths, recovery paths, and histories in which the criticality hypothesis proves inapplicable. Robustness analysis from Section 11.9 can then

ask which commitments remain acceptable across these qualitatively different possibilities.

11.11.4 Diagnostic Evidence and Early-Warning Interpretation

Some dynamical models admit observable patterns that can precede particular critical transitions. The literature on early-warning signals discusses phenomena such as slower recovery from perturbation and changes in autocorrelation or variance under specified conditions (Scheffer et al. 2009). These signals can be useful, yet they are conditional on the underlying transition mechanism, observation process, sampling design, noise structure, and scale.

A meta-framework should therefore avoid treating one indicator as a universal criticality detector. The practical use of an early-warning measure should identify the model that gives the signal meaning, the observational regime that produces it, the alternative mechanisms that can produce similar patterns, and the consequence of false positive or false negative interpretation.

Definition 11.202 (Transition-diagnostic profile). A *transition-diagnostic profile* records the hypothesized transition mechanism, selected indicators, observational scale, expected signal structure, alternative explanations, uncertainty, and practical decisions that would be affected by interpreting the field as approaching a qualitative transition.

Historical and interpretive evidence can complement formal indicators. Institutional weakening, changing coordination conventions, rapid category redefinition, loss of redundancy, or altered legitimacy can be transition-relevant without possessing a justified scalar early-warning index. The chapter's methodological pluralism therefore applies to criticality diagnosis as well as to ordinary decision analysis.

11.11.5 Intervention-Induced Transition Risk

An intervention can alter the system's location relative to a transition. A policy can change incentives, a classification can reorganize access, an infrastructure can create network dependence, a technological deployment can accelerate adaptation, or a resource shift can weaken a stabilizing buffer. Decision analysis near criticality should therefore represent the intervention as one of the forces potentially changing regime structure.

Definition 11.203 (Transition-coupled intervention). A *transition-coupled intervention* is an intervention whose modeled or plausibly interpreted effects can materially alter the accessibility, timing, mechanism, or consequence of a qualitative transition in the practical field.

The definition includes interventions intended to prevent or induce transition. Stabilization, transformation, resilience building, institutional reform, and managed phase-out can each interact with transition structure. The key methodological task is to make the coupling explicit enough that the intervention is not evaluated only through within-regime effects.

Intervention-induced transition also complicates causal evaluation. If the intervention changes the response regime, the post-intervention relation between inputs and

outcomes can differ from the relation used to justify the action. Evaluation should then include whether the intervention changed the model class or validity domain, not only whether a predicted outcome occurred.

11.11.6 Reversibility, Hysteresis, and Historical Dependence

A practical transition can be historically asymmetric. Some dynamical systems exhibit hysteresis, so reversing the parameter that contributed to a transition does not necessarily restore the previous state along the same path. Institutional and relational fields can also generate durable structures, expectations, sunk investments, classifications, dependencies, or lost capabilities that persist after an intervention is withdrawn. These mechanisms should be analyzed on their own terms even when a formal hysteresis model is unavailable.

The implication for decision methodology is that rollback and restoration are separate questions. Section 11.25 develops exit and rollback generally. Under critical-transition uncertainty, the design should also ask whether crossing a plausible transition changes the cost, feasibility, or meaning of return.

Definition 11.204 (Transition-reversibility profile). A *transition-reversibility profile* records the represented pathways of return after a qualitative change, the resources and capacities required for those pathways, the historical residues expected to persist, and the uncertainty concerning whether restoration remains reachable.

This profile can motivate preservation of redundancy, institutional memory, fallback infrastructure, or repair capacity before a transition occurs. These devices do not guarantee reversibility. They preserve practical possibility where the field permits it.

11.11.7 Staged Commitment and Option Preservation

Critical-transition uncertainty can increase the value of staged commitment when delay remains practically tolerable. A staged intervention can create information before later commitment, distribute exposure, test mechanism, or preserve alternative pathways. This logic connects directly to adaptive decision-making in Section 11.10 and experimental intervention in Section 11.20.

Staging should not be treated as universally conservative. In some fields, slow action increases the probability of an undesirable transition or closes a temporary window for beneficial transformation. The practical comparison is therefore among histories generated by different commitment schedules, including the history generated by delay.

Definition 11.205 (Transition-sensitive option profile). A *transition-sensitive option profile* records which future actions remain accessible, become newly accessible, become more costly, or become foreclosed under alternative commitment paths and plausible transition histories.

Option preservation can concern material reserves, institutional flexibility, legal authority, ecological buffers, technical interoperability, social trust, learning capacity, or other locally relevant resources. It should be represented at the scale at which the future option actually exists.

11.11.8 Multiscale Monitoring and Transition Detection

Qualitative change can appear differently across scales. A local subsystem can reorganize while aggregate indicators remain stable; an aggregate shift can emerge from many heterogeneous local changes; and leading signals at one temporal scale can be masked by faster noise or slower structural trends. Monitoring near criticality should therefore consider whether the selected resolution can observe the transition mechanism being hypothesized.

Multiscale monitoring can combine aggregate indicators, local relational measures, institutional events, qualitative reports, dynamical indicators, and mechanism-specific observations. More data is not automatically better. The monitoring architecture should select signals according to their relation to the criticality hypothesis and the practical consequences of missing a change.

Observation can also become performative. Public warning indicators can change behavior, institutional response, or expectations. The signal can therefore help prevent, delay, or accelerate the transition it was intended to detect. Section 11.4 provides the general epistemic architecture for interpreting such recursive evidence.

11.11.9 Model Plurality and Transition Disagreement

Different models can disagree about whether a transition exists, which variables organize it, where the boundary lies, and which intervention moves the system toward or away from it. This disagreement should remain visible when it changes practical conclusions. Averaging incompatible transition mechanisms into one forecast can obscure the reason the models disagree.

A useful decision record can separate at least three cases. In the first, several models support similar practical precautions despite differing mechanisms. In the second, models recommend different monitoring but similar immediate action. In the third, the practical commitment changes sharply with the selected model. The third case creates a stronger need for robustness analysis, staged action, or additional inquiry.

Definition 11.206 (Transition-model disagreement profile). A *transition-model disagreement profile* records the alternative transition mechanisms, validity domains, evidential supports, practical recommendations, and decision-sensitive disagreements among the model families considered relevant to the field.

Historical interpretation can belong in this profile. A model that captures short-run dynamics can coexist with an institutional history suggesting that the key transition variable is being misidentified. The practical architecture should preserve such remainders until evidence justifies stronger synthesis.

11.11.10 Transition-Sensitive Decision Discipline

Decision-making under critical-transition uncertainty requires a change in methodological emphasis. Local prediction remains useful, but practical judgment also attends to model validity domains, branching histories, regime-sensitive evidence, option preservation, intervention-induced transition, reversibility, and model disagreement. These concerns are additions to the ordinary decision architecture, not replace-

ments for it.

Proposition 11.207 (Transition-sensitive decision discipline). *When a defensible criticality hypothesis is materially relevant to a contemplated commitment, decision methodology should make the hypothesis, model dependence, transition-sensitive evidence, plausible regime alternatives, intervention coupling, reversibility, and reopening conditions visible at a depth proportionate to the consequences of transition and the costs of delay.*

Proposition 11.207 leaves several legitimate practical responses open. A field can justify immediate transformation, stabilization, staged experimentation, option preservation, intensified monitoring, additional research, or continued ordinary operation when the criticality hypothesis is weak. The framework does not select among these responses independently of the local history and evaluative frame.

This treatment also clarifies the relation to formal modeling. Criticality can be analyzed through dynamical systems, stochastic processes, networks, agent-based simulations, field models, or other representations when their assumptions are justified. Formal analysis can sharpen transition hypotheses, while the practical decision still requires the epistemic, normative, historical, participatory, and responsibility architecture developed across the chapter. Section 11.12 now turns to these formal and quantitative model families and includes optimization as one locally specified mode of computational decision support within them.

11.12 Formal and Quantitative Decision Models

This section specifies the principal families of formal and quantitative models available to application-dominant praxis after the methodological disciplines developed in Sections 11.1–11.11. Its role is taxonomic and architectural rather than hierarchical. The objective is to identify what different model families represent, what practical questions they can support, which assumptions make their outputs meaningful, and how their results can be combined without collapsing distinct epistemic functions into a single formal language. The discussion proceeds from statistical and causal representations through dynamical, stochastic, network, field, operator, partial-order, history-weight, agent-based, and simulation models, then treats optimization and computational search as locally specified uses of formal representation, and concludes with sensitivity analysis, model risk, and the stronger assumptions required by amplitude-like constructions. Throughout, formal models remain locally justified representations under ontological suspension. Their important practical strengths can include explicit assumptions, internal consistency, operational specification, reproducible computation, empirical calibration or testing, and disciplined comparison across counterfactual or simulated states where the field permits these functions. Their practical authority nevertheless depends on the fit between representational structure and the historically evolving relational field rather than on mathematical sophistication alone. Historical, interpretive, naturalistic, and participatory methods can disclose forms of provenance, meaning, tacit recognition, institutional context, and affected-position knowledge that formalization may compress, while those methods have their own limits of comparability, verification, transport,

and dependence on situated judgment. Section 11.6 therefore treats methodological composition as a problem of reciprocal correction rather than a fixed hierarchy.

Definition 11.208 (Formal decision-model family). A *formal decision-model family* is a specified class of mathematical or computational representations that maps selected features of a practical configuration into objects, relations, transformations, histories, or comparison structures for the purpose of diagnosis, inference, scenario construction, decision support, intervention design, monitoring, or revision.

A formal model therefore enters a wider methodological architecture. Its inputs depend on observation regimes and epistemic events; its state variables and boundaries depend on practical diagnosis; its comparison rules depend on goals and criteria; and its outputs remain subject to institutional, normative, historical, and interpretive judgment. Section 11.4 established the analytical distinction between epistemic content and practical uptake when epistemic events become performatively coupled to later evolution. Sections 11.7–11.11 then showed that action spaces, histories, decision rules, evaluative frames, and even local response regimes can evolve. Formal decision models should preserve these possibilities where they are material to the practical problem.

Table 11.12 summarizes the principal families considered here. The rows should be read as interfaces rather than mutually exclusive boxes. A single practical model can combine several families: an agent-based simulation can evolve on a network; a dynamical system can contain stochastic transitions; a 2-complex history model can carry operator-valued labels; a causal model can be embedded in a simulation; and a scenario system can compare outputs from several formally heterogeneous models. The methodological requirement is to preserve what each component means and how information moves across their interfaces.

11.12.1 Statistical Forecasting

Statistical forecasting represents empirical regularities in observed or derived variables for the purpose of anticipating future observations, states, or indicators. Its strongest contribution is often predictive calibration within a specified data-generating and measurement regime. Forecasting can support resource preparation, scheduling, capacity planning, early warning, scenario comparison, and the monitoring of deviations from expected trajectories.

A generic predictive model can be written as Equation 11.19.

$$p^{(m)}(Y_{t+h} \mid \mathcal{I}_t), \quad h \geq 1, \quad (11.19)$$

where $\mathcal{I}_t$ denotes the information represented as available at stage t , Y_{t+h} is a future observable or derived quantity, and m identifies the forecasting model. Equation 11.19 is intentionally broad. The predictive object can be a point forecast, interval, distribution, quantile, categorical probability, or another model-specific representation.

Forecast accuracy and practical usefulness should remain distinct. A model can predict an indicator accurately while omitting the relations through which an intervention would change that indicator. Conversely, a causal or dynamical model

Table 11.12: Formal and quantitative model families and their characteristic representational roles.

Model family	Primary representational object	Characteristic practical contribution
Statistical forecasting	Conditional regularities in observed data	Predictive distributions, intervals, short- to medium-horizon anticipation
Causal models	Intervention-sensitive dependency structure	Mechanism-sensitive counterfactual and intervention reasoning
Dynamical models	State evolution under transformation rules	Trajectories, attractors, thresholds, fast-slow change
Stochastic models	Transition structures with explicit randomness	Distributional uncertainty, path variation, stochastic transitions
Network / higher-order models	Relational topology and multi-actor interaction	Diffusion, concentration, coordination, systemic dependence
Field / operator models	Distributed conditions and transformation operators	Spatially or relationally varying influence and performative change
Operator algebra	Ordered composition of transformations	Sequence dependence, noncommutativity, intervention-order effects
Partial-order / 2-complex models	Historical-relational event structures	Event precedence, branching histories, extended subjects and relations
History weights / kernels	Relative support or transition structure over histories	Scenario weighting, accessibility, transition potential, updating
Agent-based models	Heterogeneous interacting computational agents	Emergence, adaptation, local rules, institutional and behavioral heterogeneity
Simulation	Generated ensembles of model trajectories	Stress testing, scenario exploration, mechanism experimentation
Optimization / search	Objectives, constraints, feasible regions, and search procedures	Conditional selection or design within an explicitly specified formal problem
Sensitivity analysis	Dependence of outputs on assumptions and inputs	Fragility diagnosis, influential parameters, structural comparison
Model-risk analysis	Uncertainty created by the modeling architecture	Boundary, specification, transport, implementation, and use risk
Amplitude-like models	Composition-sensitive complex-valued history objects	Optional interference-like or compositional structures under stronger semantics

with weaker short-horizon predictive accuracy can still provide valuable intervention structure. Forecasting therefore answers a different methodological question from causal identification.

The information set $\mathcal{I}_t$ also carries historical and institutional assumptions. Observations can reflect classification systems, reporting incentives, sensor placement, missingness, strategic behavior, and earlier interventions. Where observation is performative, the forecasting process itself can change future data. A forecast published by a powerful institution can alter expectations, coordination, investment, or behavior, thereby becoming an epistemic event within the field represented by the forecast.

Definition 11.209 (Forecast-use profile). A *forecast-use profile* records the forecast object, horizon, data and observation regime, calibration domain, intended practical

use, consequential decisions informed by the forecast, known performative effects, and conditions under which predictive validity should be reassessed.

The profile prevents a forecast validated for one horizon, population, or observational regime from acquiring unsupported authority in another. It also makes forecast revision compatible with the model-versioning architecture developed in Section 11.10.

11.12.2 Causal Models

Causal models represent intervention-sensitive dependency structures. Their practical role is to distinguish patterns that help predict observations from structures that support claims about how selected changes can alter later outcomes or relational configurations. In application-dominant praxis, causal reasoning is especially important when a decision concerns intervention rather than passive anticipation.

A generic structural representation can be written as Equation 11.20.

$$X_j = f_j(\mathbf{Pa}_j, U_j), \quad j = 1, \dots, J, \quad (11.20)$$

where $\mathbf{Pa}_j$ denotes represented parent conditions for X_j , U_j collects exogenous or unresolved influences, and the family of functions f_j specifies the modeled generative dependencies. Equation 11.20 can be deterministic, stochastic, static, sequential, or embedded in a broader dynamical model.

The practical force of a causal model depends on more than graphical or algebraic form. Intervention semantics, temporal order, boundary assumptions, transport across contexts, measurement validity, and the stability of relevant mechanisms all matter. A model that supports a local intervention claim in one institutional setting can lose validity after the intervention changes actor incentives, institutional roles, or the observation regime itself.

GR also gives causal models a historical-relational interpretation. Causes need not be represented only as isolated variables. A causal condition can be a relational configuration, institutional arrangement, accumulated history, event sequence, or capacity structure. The relevant causal object can therefore be extended and path-dependent. In some applications, changing one event in a historical-relational subject requires regenerating downstream relations rather than treating the subject as unchanged apart from one variable.

Definition 11.210 (Practical causal claim). A *practical causal claim* is a scoped statement connecting a represented intervention or generative condition to a change in one or more later variables, relations, histories, capacities, or action possibilities under specified assumptions and contextual conditions.

Causal claims should travel with their scope. A decision can combine causal evidence from experiments, observational studies, historical comparison, mechanism analysis, simulation, or institutional knowledge while preserving disagreements among them. This keeps causal modeling inside the methodological pluralism established earlier in the book.

11.12.3 Dynamical Models

Dynamical models represent the evolution of a state or relational configuration under transformation rules. They are well suited to problems involving feedback, path dependence, persistence, oscillation, attractors, thresholds, critical transitions, fast-slow processes, delayed effects, and changing intervention response.

A generic stage-dependent dynamical model is stated in Equation 11.21.

$$\omega_{t+1} = F_t^{(m)}(\omega_t, a_t, e_t; \theta_t), \quad (11.21)$$

where ω_t is the represented configuration, a_t is practical action, e_t is an epistemic or other event, and θ_t collects model parameters. Equation 11.21 explicitly permits epistemic events to alter later evolution, consistent with Section 11.4.

The state ω_t can itself be heterogeneous. It can contain continuous variables, categorical institutional states, relational networks, actor capacities, fields, or embedded historical objects. The transformation rule can also change through time. Section 11.8 introduced transformative histories in which the effective generative rule evolves; a dynamical model can therefore be extended to allow F_t to become an object of evolution rather than an immutable background law.

A useful dynamical representation should distinguish three questions. The first concerns the local response of the model around a represented configuration. The second concerns the larger qualitative structure of trajectories and basins. The third concerns whether the model itself remains appropriate as the practical field changes. A model that is locally accurate can become inadequate after an institutional transition, category change, or critical transformation.

Definition 11.211 (Dynamical validity region). A *dynamical validity region* is the set of represented configurations, time horizons, intervention magnitudes, parameter regimes, and institutional conditions within which a specified dynamical model is considered sufficiently adequate for its intended practical use.

This definition connects dynamical modeling to adaptive decision-making. Crossing the validity region can itself be an update condition that triggers model revision, additional observation, or a shift to another representation.

11.12.4 Stochastic Models

Stochastic models represent transition or observation structures in which modeled uncertainty is expressed through probabilistic objects. Their practical value arises where repeated variation, random disturbance, uncertain transitions, noisy observation, or distributional consequences are meaningfully represented probabilistically.

A generic stochastic transition kernel can be written as Equation 11.22.

$$K_t^{(m)}(d\omega' \mid \omega, a, e), \quad (11.22)$$

where the kernel assigns a model-specific probability measure over later configurations ω' conditional on the present configuration, action, and relevant event. Equation 11.22 has explicitly probabilistic semantics, in contrast with the more general

transition-potential language used later in this section.

Probabilistic representation is strongest where probabilities have a defensible interpretation. The source can be repeated empirical frequencies, calibrated statistical models, explicit stochastic mechanisms, Bayesian uncertainty under stated assumptions, or another well-defined construction. Deep uncertainty, structural model disagreement, and unknown history spaces can exceed the scope of one stochastic kernel. Those conditions call for the scenario, robustness, and model-plurality architectures developed in Sections 11.8 and 11.9.

Stochasticity can enter at several levels. The practical field can contain random disturbance; observation can be noisy; actor behavior can be represented probabilistically; parameters can be uncertain; and transitions between institutional states can carry stochastic components. These locations should remain distinguished because they imply different intervention and learning strategies.

Definition 11.212 (Stochasticity-location profile). A *stochasticity-location profile* records where probabilistic structure enters a model, what semantics justify it, which quantities remain structurally uncertain, and how stochastic assumptions affect practical conclusions.

The profile also helps prevent a probability distribution from absorbing uncertainty that is actually caused by contested boundaries, missing actors, changing mechanisms, or model-family disagreement.

11.12.5 Network and Higher-Order Models

Network models represent relational structure explicitly. They are useful where practical effects depend on connectivity, centrality, clustering, brokerage, dependency, diffusion, coordination, exposure, or the concentration of relational control. Higher-order models extend pairwise networks when interactions among three or more positions have irreducible structure for the practical question.

A basic network representation can be written as $G = (V, E, \lambda)$, where V contains represented positions, E contains pairwise relations, and λ contains relevant labels or attributes. A higher-order representation can add a family of interaction objects $\mathcal{E}^{(k)}$ for relations involving k positions. The resulting object is useful when the effect of a group relation cannot be reconstructed adequately from pairwise edges alone.

The meaning of an edge requires discipline. A communication tie, authority relation, trust relation, financial exposure, knowledge dependency, and shared institutional membership should not be treated as equivalent merely because each can be drawn as a line. Multiplex models can preserve several relation types simultaneously, while weighted or directed edges can represent asymmetry where justified.

Networks also interact with historical-relational subjects. A represented node can itself contain internal relational structure, memory, capacities, or an event history. A network of point nodes is therefore one modeling choice rather than a default ontology of social subjects. Nested or higher-order models can preserve the internal structure of selected subjects when that structure affects external relations.

Definition 11.213 (Relational representation profile). A *relational representation profile* records the meaning of nodes or positions, relation types, directionality, weights,

higher-order interactions, temporal updating rules, observation boundaries, and the practical questions for which the relational representation is intended.

Network interventions can also change the topology that made the intervention attractive. Removing a central dependency, adding redundancy, creating a coordination hub, or changing an information channel can reorganize later diffusion and power. Decision support should therefore evaluate both immediate network effects and the generated relational architecture.

11.12.6 Field and Operator-Valued Models

Field models are useful where relevant conditions vary across space, relational position, scale, or another continuous or distributed domain. A field can represent opportunity, constraint, exposure, trust, information accessibility, institutional reach, environmental condition, or another distributed quantity. Operator-valued models become useful where local events or fields parameterize transformations of the represented configuration.

Let $\varphi_t(z)$ denote a model-specific field over positions z in a domain D . A distributed practical configuration can then be transformed through an operator family conditioned on the field. A schematic representation is stated in Equation 11.23.

$$\omega_{t+1} = \Phi_t[\varphi_t; a_t, e_t]\omega_t. \quad (11.23)$$

Equation 11.23 should be interpreted according to the chosen model. The bracketed field can parameterize a linear operator, nonlinear transformation, local update rule, or another transformation family. The notation does not imply a quantum ontology.

This representation is especially convenient for performative epistemic events. Observation can first produce a readout in a representation space, while recognition, classification, communication, or institutional uptake produces a field or operator that changes subsequent evolution. Section 11.4 established the typed distinction between these stages. Field and operator models provide one computational language for representing their coupling.

Definition 11.214 (Performative field). A *performative field* is a model-specific distributed representation through which an epistemic, institutional, normative, or practical event alters the transformation conditions experienced across positions or relations in the represented configuration.

A performative field can be local, heterogeneous, delayed, or scale-dependent. It can alter only selected parts of the configuration. This makes field representations useful where the same announcement, classification, rule, or signal has different consequences across relational positions.

11.12.7 Operator Algebra and Order-Sensitive Composition

Operator algebra provides a convenient formalism when practical transformations compose and the order of composition matters. Section 11.7 introduced order-sensitive decisions. The present subsection specifies how an operator representation

can make that dependence explicit while preserving the distinction between formal composition and ontological claim.

Let Φ_a and Φ_b represent two practical or epistemically mediated transformations. Order sensitivity can be expressed by Equation 11.24.

$$\Phi_b \circ \Phi_a \neq \Phi_a \circ \Phi_b. \quad (11.24)$$

Equation 11.24 can represent many practical structures. Participation followed by design can produce a different institutional object from design followed by participation. Classification followed by resource allocation can differ from allocation followed by classification. Capability building before delegation can differ from delegation before capability building. The inequality therefore represents path-sensitive composition where the model warrants it.

An operator algebra can include identity transformations, admissible composition, partial domains, inverses or approximate reversals, commutation relations, and distinguished subalgebras for different kinds of intervention. Partial operators are often appropriate because an action can be defined only on configurations satisfying particular institutional or capability conditions.

Definition 11.215 (Practical operator algebra). A *practical operator algebra* is a model-specific collection of transformations together with stated rules for admissibility, composition, order dependence, domain, and where relevant reversal or approximation, used to represent how practical or epistemic events transform a relational configuration.

Operator language becomes especially valuable when a decision problem concerns sequencing rather than isolated action selection. It can also expose when two interventions treated as interchangeable in prose actually have different composition structures.

11.12.8 Partial-Order and 2-Complex History Models

Partial-order and 2-complex models represent historical-relational structure directly. They are useful when event precedence is meaningful while a single total timeline would add unsupported ordering, or when subjects and relations possess higher-order historical organization that point-state models suppress.

A partially ordered event history can be represented as $(V, \preceq, \lambda)$, where V is a set of events, $\preceq$ is a precedence relation, and λ supplies model-specific labels. A labeled 2-complex can extend this structure through vertices, edges, and faces. A convenient schematic form is given in Equation 11.25.

$$\mathcal{C} = (V, E, F, \preceq, \lambda). \quad (11.25)$$

In Equation 11.25, the interpretation of vertices, edges, faces, precedence, and labels is model-specific. Vertices can represent events; edges can represent relational or transition structure; faces can represent higher-order composition, persistence, or interaction histories. The same mathematical object can support different semantics, so those semantics should be stated explicitly.

For historical-relational subjects, a 2-complex can preserve internal event structure together with external relations. A subject can therefore be represented as a finite subcomplex or a structured region of a larger history rather than as a timeless point. Practical interventions can add, remove, relabel, or reorganize parts of the complex, and epistemic events can change the represented continuation space.

Definition 11.216 (History-complex representation). A *history-complex representation* is a partial-order or cell-complex model in which events, relations, and higher-order historical structures are represented explicitly so that alternative continuations, composition, and subject persistence can be analyzed without reducing history to a sequence of independent states.

This family is particularly useful for scenario construction and trajectory credibility. It remains optional. A narrative, process-tracing, dynamical, graph, or agent-based representation can preserve the relevant history more effectively in other applications.

11.12.9 History Weights and Transition Kernels

History weights and transition kernels provide formal mechanisms for differentiating among admissible futures. Section 11.8 introduced this architecture for scenario construction. The present subsection clarifies its role within a broader formal taxonomy.

Let $\mathcal{H}_t^{(m)}$ denote the model-specific admissible history family from stage t . A non-negative history-weight function is written in Equation 11.26.

$$W_t^{(m)} : \mathcal{H}_t^{(m)} \longrightarrow \mathbb{R}_{\geq 0}. \quad (11.26)$$

The semantics of Equation 11.26 can be probability, empirical frequency, plausibility, accessibility, simulation mass, transition propensity, or another explicitly defined quantity. Normalization is appropriate only where the chosen semantics require it.

A transition kernel can provide a more local construction. The general nonnegative form in Equation 11.27 does not yet assign probabilistic semantics.

$$K_t^{(m)}(\omega' \mid \omega, e, a) \geq 0. \quad (11.27)$$

Equation 11.27 can represent a transition potential, accessibility weight, or another local relation. If the kernel is normalized and given probability semantics, it becomes a stochastic transition model of the kind considered in Subsection 11.12.4. This typed distinction prevents generic history weighting from being silently interpreted as probability.

Epistemic events can affect these models in at least two different ways. They can reweight histories already present in $\mathcal{H}_t^{(m)}$, or they can change the history family itself by generating or foreclosing branches. These operations should remain distinct because the second changes the support of the future representation rather than only the relative weight assigned within a fixed support.

Definition 11.217 (History-weight provenance). A *history-weight provenance record* states the semantics, empirical or theoretical basis, normalization rule where ap-

plicable, updating procedure, scope, and known limitations of a history-weight or transition-potential construction.

This provenance is essential when weighted histories inform consequential decisions. A visually precise weighted scenario tree can otherwise conceal a highly contestable interpretation of what its weights mean.

11.12.10 Agent-Based Models

Agent-based models represent heterogeneous interacting computational agents whose local rules generate larger-scale patterns. They are useful when aggregate behavior emerges from adaptation, bounded information, local interaction, institutional rules, network position, learning, imitation, strategic response, or heterogeneous capacities.

A generic agent update can be written as Equation 11.28.

$$s_{i,t+1} = G_i^{(m)}(s_{i,t}, \mathcal{N}_{i,t}, \omega_t, a_t, e_t; \theta_i), \quad (11.28)$$

where $s_{i,t}$ is the represented state of agent i , $\mathcal{N}_{i,t}$ summarizes relevant relational neighbors or interaction structure, and the remaining terms represent field, action, event, and agent-specific parameters. Equation 11.28 can be deterministic or stochastic.

The word *agent* is a computational role rather than a complete theory of subjectivity. A historical-relational subject can be represented by one computational agent, several interacting sub-agents, a structured internal model, or another object. The appropriate representation depends on whether internal history and relations materially affect the practical question.

Agent-based models are especially useful for examining emergent consequences of rules that are locally simple but collectively complex. They can explore coordination, diffusion, segregation, institutional learning, strategic adaptation, trust, and the performative response to decision rules. Their flexibility also creates model risk: behavioral rules, calibration, initialization, network structure, and adaptation assumptions can strongly shape the generated histories.

Definition 11.218 (Agent-rule provenance). An *agent-rule provenance record* states how agent types, behavioral rules, learning rules, interaction structures, heterogeneity, initialization, and calibration were constructed and which practical claims they are intended to support.

Agent-based outputs should therefore be interpreted as conditional consequences of a specified generative architecture rather than direct predictions of social behavior unless stronger validation supports that use.

11.12.11 Simulation

Simulation generates model trajectories by executing a formal representation under specified initial conditions, parameters, interventions, events, and stochastic realizations. Its practical value lies in exploring consequences that are analytically difficult to derive, stress-testing mechanisms, comparing pathways, and exposing interactions

among assumptions.

A simulation ensemble can be represented schematically as Equation 11.29.

$$\mathcal{S}^{(m)} = \left\{ h_r^{(m)} \mid r = 1, \dots, R \right\}, \quad (11.29)$$

where $h_r^{(m)}$ is one generated trajectory or history under model m . The ensemble can arise from stochastic draws, parameter sweeps, different scenarios, alternative interventions, or combinations of these sources.

Simulation does not create evidence by itself. A simulation result is evidence about the behavior of the specified model under the stated conditions. Its relevance to the practical world depends on model adequacy, calibration, validation, correspondence between simulated and observed objects, and the intended inferential task.

This distinction is particularly important for exploratory simulation. A model can be useful because it reveals a possible mechanism, threshold, failure mode, or unexpected interaction even when it is not calibrated for prediction. Conversely, a well-calibrated simulator can still omit institutional or historical structures that matter for intervention.

Definition 11.219 (Simulation-use class). A *simulation-use class* specifies whether a simulation is being used primarily for exploration, explanation, prediction, stress testing, design comparison, training, or another practical function, together with the validation burden appropriate to that function.

Simulation should therefore be linked to the epistemic task it performs. The same computational output can carry different practical authority when used for exploration than when used to justify a high-stakes irreversible commitment.

11.12.12 Optimization and Computational Search

Optimization and computational search are formal procedures for comparing candidate actions, designs, schedules, trajectories, or parameter configurations after a practical problem has been represented through objectives, constraints, feasible regions, transition assumptions, or other comparison structures. Their methodological role is local: they can identify solutions within a specified formalization while leaving open whether that formalization captures all considerations relevant to practical commitment.

A basic local optimization problem can be expressed in Equation 11.30.

$$a^* \in \arg \operatorname{opt}_{a \in \mathcal{F}_t^{(m)}} J_t^{(m)}(a), \quad (11.30)$$

where $J_t^{(m)}$ denotes a model- and stage-specific objective or comparison functional and $\mathcal{F}_t^{(m)}$ denotes the represented feasible region. Equation 11.30 is intentionally local. The objective can be scalar, vector-valued, lexicographically ordered, constrained by protected conditions, or embedded in a dynamic or robust problem. The feasible region can also change as capacities, authority, institutions, knowledge, or earlier choices alter the action space.

Optimization therefore inherits the situated evaluative architecture of Section 11.3. A scalar objective can be appropriate when the relevant practical dimensions admit a justified common ordering. Multiple objectives can remain vector-valued when scalarization would suppress important value structure. Constraints can represent material limits, institutional authority, legal requirements, safety conditions, ecological boundaries, or other locally justified restrictions, but their formal appearance does not make these heterogeneous meanings interchangeable.

The result is also model-dependent. Different boundaries, transition rules, horizons, uncertainty sets, subject representations, or conversion rules can produce different optima without any computational error. Robust optimization can compare performance across a specified uncertainty set, and dynamic optimization can represent temporally linked decisions, while the broader robustness architecture of Section 11.9 remains available for uncertainties and values that do not fit one optimization problem.

Definition 11.220 (Optimization-use profile). An *optimization-use profile* records the objective or comparison rule, feasible-set construction, constraints, temporal horizon, model family, uncertainty representation, value-conversion assumptions, search procedure, and practical conclusion for which an optimization result is being used.

Non-convexity, discrete institutional rules, changing action spaces, path dependence, and critical-transition uncertainty can make local optima or locally calibrated objectives poor guides to wider practical judgment. These conditions do not remove the value of optimization. They specify the domain in which an optimization result should be interpreted. Near a possible qualitative transition, for example, the relevant question can shift from finding the best point inside one regime to comparing histories that enter different regimes, as developed in Section 11.11.

Optimization and computational search therefore belong inside the formal-method repertoire rather than above it. They can organize large decision spaces, reveal binding constraints, identify efficient regions, and support design exploration. Final practical commitment still depends on the epistemic, normative, historical, participatory, responsibility, and reversibility conditions developed elsewhere in the chapter.

11.12.13 Sensitivity Analysis

Sensitivity analysis examines how model outputs, decisions, rankings, or qualitative conclusions depend on parameters, assumptions, initial conditions, boundaries, criteria, and structural choices. Its practical role is to expose where apparent precision is supported by stable structure and where it depends on fragile modeling decisions.

For a scalar output $Q(\theta)$, a local sensitivity can be represented by Equation 11.31.

$$S_j = \frac{\partial Q}{\partial \theta_j}, \quad (11.31)$$

where the derivative is meaningful only when the model and parameterization support such local analysis. Equation 11.31 is one narrow form of sensitivity analysis. Finite perturbations, global sensitivity, scenario comparison, structural alternatives,

boundary variation, and model-family comparison can be more appropriate where the response is nonlinear, discontinuous, categorical, or historically path-dependent.

GR broadens the object of sensitivity beyond numerical parameters. A practical conclusion can be sensitive to:

- the represented subject boundary;
- relation type or network topology;
- event order;
- history-space construction;
- observation regime;
- criterion priority;
- institutional implementation assumption;
- model family itself.

These forms of sensitivity should be recorded even where they cannot be differentiated numerically.

Definition 11.221 (Decision-sensitivity profile). A *decision-sensitivity profile* records the parameters, assumptions, boundaries, model structures, criteria, histories, and institutional conditions whose plausible variation materially changes a practical conclusion, together with the direction and practical significance of that change where these can be characterized.

Sensitivity analysis connects directly to robustness. A highly sensitive model can still support a robust decision if the relevant variations leave all admissible conclusions within an acceptable region. Conversely, a numerically stable output can conceal structural fragility if the model family or boundary is wrong.

11.12.14 Model Risk

Model risk is the practical risk generated by relying on a representation that is incomplete, misspecified, transported beyond its validated domain, poorly implemented, strategically manipulated, or assigned more authority than its epistemic status supports. Model risk therefore concerns both the model and the institutional relation through which model output enters consequential praxis.

Definition 11.222 (Model risk). *Model risk* is the possibility of materially adverse practical consequence arising from the construction, estimation, calibration, implementation, interpretation, governance, or use of a formal model and from mismatch between the model's representational scope and the practical conclusion drawn from it.

A useful model-risk decomposition distinguishes several loci. *Boundary risk* concerns omitted actors, relations, scales, or histories. *Specification risk* concerns incorrect or inadequate model structure. *Parameter risk* concerns uncertain or unstable parameter values. *data and observation risk* concerns measurement, selection, missingness, or performative observation. *transport risk* concerns use outside the context in which the model was supported. *implementation risk* concerns errors in software, numerical procedures, interfaces, or organizational execution. *use risk* concerns interpreting the model beyond the claims it can support. *governance risk* concerns

concentration of authority, opacity, weak contestability, or lack of responsibility for model revision.

Model plurality can reduce some forms of model risk by exposing structural dependence, while it can create additional coordination and interpretation burdens. Independent models that share the same omitted boundary or data-generating assumptions do not provide independent protection merely because their mathematical forms differ.

Definition 11.223 (Model-risk register). A *model-risk register* records material model dependencies, known failure modes, validation limits, monitoring signals, responsible positions, version history, fallback models or non-model procedures, and conditions for suspension, revision, or retirement.

The register converts model risk into an object of ongoing governance. This becomes especially important for models embedded in automated systems, institutional routines, or long-lived infrastructure where the model can continue shaping action after its original assumptions have changed.

11.12.15 Amplitude-Like Models under Stronger Assumptions

Amplitude-like models form an optional extension of the history-based architecture. They become potentially useful where the intended formalism requires composition-sensitive complex-valued objects whose phases or interference-like relations have a defined analytical role. Their use requires substantially stronger semantics than the nonnegative history weights and transition potentials introduced in Subsection 11.12.9.

Let an amplitude-like assignment be represented by Equation 11.32.

$$A^{(m)} : \mathcal{H}^{(m)} \longrightarrow \mathbb{C}. \quad (11.32)$$

Equation 11.32 alone provides a complex-valued label over histories. It does not yet specify how amplitudes compose, how alternatives combine, what phase means, how an observation is represented, or how the resulting object maps to empirically or practically interpretable quantities.

For a family of histories $B \subseteq \mathcal{H}^{(m)}$, one possible compositional object is stated in Equation 11.33.

$$\mathcal{A}^{(m)}(B) = \sum_{h \in B} A^{(m)}(h). \quad (11.33)$$

Equation 11.33 becomes analytically meaningful only after the model specifies why histories should compose through complex addition and what empirical or conceptual phenomenon is represented by the resulting phase-sensitive quantity. A further mapping from $\mathcal{A}^{(m)}(B)$ to an observable or decision-relevant measure also requires explicit justification.

Definition 11.224 (Amplitude-semantics package). An *amplitude-semantics package* specifies the meaning of the complex-valued history object, composition rule, phase structure, observation or readout map, empirical interpretation, calibration or es-

timation procedure where applicable, and the additional explanatory or computational value obtained relative to a nonnegative history-weight model.

A 2-complex representation does not by itself supply this package. Spin-foam-inspired combinatorial structure, partial ordering, or operator composition can be useful without importing quantum amplitudes. Amplitude-like models become justified only where their stronger structure performs an identified analytical task that simpler representations cannot perform adequately.

This discipline preserves openness. Future GR work can develop amplitude-like or other richer history formalisms where they prove useful, while current applied methodology can rely on statistical, causal, dynamical, stochastic, network, operator, partial-order, simulation, and nonnegative history-weight models according to problem structure.

Proposition 11.225 (Representational plurality of formal decision models). *No single formal family considered in this section is sufficient by virtue of mathematical form alone for the full range of application-dominant praxis. Practical adequacy depends on which actors, relations, histories, transformations, uncertainties, values, scales, and institutional conditions the model preserves, together with how its outputs are interpreted and revised.*

The practical consequence of Proposition 11.225 is methodological combination with preserved interfaces. A statistical forecast can anticipate a near-term quantity, a causal model can represent an intervention mechanism, a network model can reveal concentrated dependency, a dynamical model can expose a threshold, an agent-based simulation can explore adaptation, and a history model can preserve event order and long-horizon branching. Their outputs can inform one practical architecture while retaining their distinct assumptions and epistemic roles.

Formal and quantitative models also leave remainders. Categories can have contested meanings; institutional rules can operate differently from their formal specification; actors can interpret and strategically respond to models; historical experience can change the meaning of apparently identical variables; and values can resist commensuration. Section 295 therefore turns to historical and interpretive practical analysis. Its role is complementary: to reconstruct meanings, trajectories, institutional formation, classification, narrative, and situated understanding that formal models can use, challenge, or leave deliberately unresolved.

11.13 Historical and Interpretive Practical Analysis

Formal and quantitative decision models make selected structures, dependencies, trajectories, uncertainties, and transformation rules explicit. Application-dominant praxis also encounters practical objects whose identity and consequence depend materially on historical formation, institutional memory, situated meaning, interpretation, and the ways actors understand the relations in which they participate. The role of the present section is to specify historical and interpretive practical analysis as a positive methodological family within applied praxis. Its objective is to reconstruct how practical configurations became possible, how historically formed subjects and institutions carry earlier events into present action, how meanings organize response,

and under what conditions an interpretation developed in one setting can inform another. The discussion proceeds through historical precedent, historical-relational subject reconstruction, institutional memory, path dependence, contextual interpretation, legal interpretation, cultural meaning, local knowledge, narrative understanding, and conditions of interpretive transfer. The method is reconstructive and comparative. Historical and interpretive materials are treated as disciplined forms of access whose claims remain evidentially constrained, revisable, and interoperable with the formal and quantitative methods developed in Section 11.12.

Definition 11.226 (Historical and interpretive practical analysis). *Historical and interpretive practical analysis* is a family of application-oriented methods that reconstructs temporal formation, historically extended subjects, institutional memory, path dependence, situated meanings, rule interpretation, cultural significance, local practical knowledge, and narrative configuration in order to improve practical diagnosis, decision, intervention, evaluation, and revision.

The object of analysis can be an institution, subject, category, relation, practice, event sequence, rule, narrative, or practical field. Different objects call for different evidential materials. Archival records, administrative documents, legal texts, institutional records, interviews, correspondence, testimony, artifacts, observational records, local classifications, and prior evaluations can each contribute where their provenance and representational limits are understood. Historical and interpretive analysis therefore has its own evidential architecture rather than functioning as unrestricted contextual commentary.

Table 11.13 summarizes the analytical dimensions developed below. The rows are mutually connected. A historical precedent is interpreted through categories; institutional memory is carried through narratives and records; local knowledge can reveal path-dependent constraints; legal interpretation operates within institutional histories; and cultural meaning can shape the practical effects of otherwise similar formal interventions. The purpose of differentiation is therefore analytical clarity rather than methodological isolation.

11.13.1 Historical Precedent

Historical precedent provides practical material for comparison among earlier situations, interventions, failures, repairs, and institutional responses. Its use is strongest when the comparison reconstructs the conditions that made an earlier episode comparable to the present case. A prior intervention can inform present judgment through mechanism, sequencing, institutional capacity, implementation difficulty, distributional consequence, or failure pattern even when the earlier case differs in other respects.

Definition 11.227 (Historical precedent profile). A *historical precedent profile* records the earlier practical situation, relevant actors and relations, problem formulation, institutional conditions, available action space, intervention sequence, observed consequences, unresolved uncertainty, and the dimensions on which comparison with the present situation is being made.

The profile prevents a precedent from operating as an unexamined analogy. Similar surface outcomes can emerge from different generative relations, while appar-

Table 11.13: Historical and interpretive dimensions of practical analysis.

Analytical dimension	Primary practical object	Characteristic contribution
Historical precedent	Earlier practical episodes and trajectories	Comparison of prior conditions, responses, consequences, and transfer assumptions
Subject reconstruction	Historically extended relational subjects	Recovery of formative events, internal relations, capacities, classifications, and changing standing
Institutional memory	Records, routines, precedents, skills, and inherited obligations	Preservation and reconstruction of prior learning, reasons, failures, and unresolved commitments
Path dependence	Sequentially generated constraints and capabilities	Identification of reinforcement, lock-in, option generation, and historically contingent reachability
Contextual interpretation	Situated meanings and practical understandings	Interpretation of actions, categories, and evidence within their operative setting
Legal interpretation	Rules, authorities, precedents, and institutional competence	Reconstruction of operative legal meaning, authorization, obligation, and contestability
Cultural meaning	Symbols, conventions, identities, expectations, and practices	Analysis of meaning-mediated response and practical acceptability
Local knowledge	Situated experiential and operational knowledge	Recovery of field-level mechanisms, constraints, capacities, and early signals
Narrative understanding	Temporal accounts linking events, actors, and consequences	Reconstruction of practical sense-making, responsibility, expectation, and future orientation
Interpretive transfer	Translation across settings, times, institutions, and categories	Identification of correspondence, remainder, transformation, and conditions of portability

ently different episodes can share important structural mechanisms. Practical use therefore depends on specifying the dimension of correspondence. A precedent can be informative because it shares an institutional bottleneck, a sequencing problem, a particular dependence relation, or a form of implementation failure even where the substantive domain differs.

Historical precedent also contains negative information in a broad sense: abandoned alternatives, failed coordination, missing capabilities, unintended consequences, and pathways that were later repaired can all enlarge the present action space. Earlier actors may also have faced options that no longer exist, while present actors may possess capacities unavailable before. A useful precedent profile therefore records historical action spaces and later transformations rather than comparing only realized outcomes.

The interpretation of precedent remains temporally situated. Categories, legal authorities, infrastructures, communication technologies, social expectations, and institutional capacities can change. A successful earlier intervention can consequently become poorly transportable after the surrounding relational field changes. Historical precedent supports practical reasoning when it is reconstructed as a conditional relation among situations, responses, and consequences rather than as a timeless template.

11.13.2 Historical-Relational Subject Reconstruction

Application-dominant praxis often depends on subjects whose present capacities, identities, obligations, vulnerabilities, and expectations are products of earlier relations and events. Historical-relational subject reconstruction preserves this temporal structure. Its practical purpose is to avoid treating a subject as a point-like bearer of fixed attributes when the relevant practical object is better understood as an extended configuration with internal history and external relations.

Definition 11.228 (Historical-relational subject reconstruction). *Historical-relational subject reconstruction* is the method of representing a practical subject through the events, relations, classifications, capacities, institutional positions, commitments, and transformations that materially constitute its present practical configuration.

The reconstructed subject can be an individual, organization, institution, community, technical system, collective, or another bounded practical object where that boundary is itself methodologically justified. Relevant history can include formative decisions, membership changes, contractual or legal transformations, resource accumulation, prior harms, learning, institutional recognition, loss of capacity, and changes in relational position. The reconstruction therefore differs from a chronological biography. It selects historical structure according to the practical question while recording the exclusions that selection creates.

Where formal analysis benefits from explicit event structure, a historical-relational subject can be represented through partially ordered events, networks, higher-order relations, labeled 2-complexes, or other models discussed in Section 11.12. Historical and interpretive reconstruction supplies meaning and provenance to those formal objects. A vertex can represent an event only after the event has been identified and interpreted; an edge can represent a relation only after its substantive meaning and temporal scope have been specified. Formal and interpretive representations therefore constrain and correct one another.

Definition 11.229 (Subject-history dossier). A *subject-history dossier* is a versioned record of the formative events, relations, classifications, capabilities, obligations, disputed interpretations, and boundary assumptions used to reconstruct a historical-relational subject for a specified practical purpose.

The dossier also supports revision. An epistemic event can reveal a previously omitted relation, change the interpretation of an earlier event, or alter the subject through recognition and institutional uptake. Subject reconstruction therefore participates in the evolving-field architecture developed in Sections 11.4–11.10.

11.13.3 Institutional Memory

Institutional memory concerns the practical persistence of knowledge, reasons, capabilities, commitments, failures, and unresolved questions across time. Records are one component of memory, while operative memory also depends on retrieval, interpretation, role continuity, training, routines, authority, and interfaces through which past information can inform present action. A large archive can coexist with weak institutional memory when records are inaccessible, decontextualized, or disconnected from decision processes.

Definition 11.230 (Practical institutional memory). *Practical institutional memory* is the capacity of an institution or collective to preserve, retrieve, interpret, and operationally reconnect materially relevant records, reasons, experiences, skills, responsibilities, and unresolved questions across changes in personnel, structure, and practical context.

Historical and interpretive analysis can reconstruct institutional memory from decision records, correspondence, procedural histories, operational routines, earlier evaluations, maintenance logs, legal or administrative materials, and the recollections of participants. The objective is not merely to recover what happened. It is to establish which reasons and constraints informed earlier action, how later actors inherited them, and where information or responsibility was lost during institutional transmission.

A useful applied object is the *memory interface*: the procedure or relation through which an earlier practical state becomes available to later actors. Handover documents, institutional repositories, recurring review procedures, professional communities, shared technical standards, and durable roles can each function as memory interfaces. Their reliability depends on selection, accessibility, interpretability, and preservation of context.

Institutional forgetting can itself become a generative condition. A temporary exception can harden into routine after its original justification is forgotten; an earlier failure can recur after diagnostic knowledge disappears; or a historical obligation can remain materially active while losing explicit institutional recognition. Practical diagnosis should therefore ask both what an institution remembers and what its current memory architecture makes difficult to recover.

11.13.4 Path Dependence

Path dependence analyzes how earlier events and sequences alter later possibilities, costs, capacities, expectations, and institutional arrangements. Its practical importance lies in distinguishing a present constraint that is technically necessary from one produced historically through reinforcement, investment, coordination, classification, learning, or accumulated commitment. The same present configuration can therefore carry different revision possibilities depending on how it was formed.

Definition 11.231 (Practical path dependence profile). A *practical path dependence profile* reconstructs the sequence of materially relevant events and reinforcement mechanisms through which earlier states or decisions altered the reachability, cost, legitimacy, capacity, or consequence structure of later practical options.

The profile can include increasing returns, network effects, sunk investment, legal commitments, organizational learning, trust formation, accumulated maintenance, category stabilization, or other mechanisms where they are empirically and interpretively supported. The method should identify the pathway connecting earlier events to present consequences. Historical sequence alone does not establish path dependence.

Path dependence can constrain action, but it can also generate capability. A durable institution, accumulated expertise, trusted coordination routine, or main-

tained infrastructure can create future possibilities precisely because earlier action has been reinforced. Practical analysis therefore tracks both *path-generated constraint* and *path-generated capacity*. This dual structure is important for intervention design: dismantling a constraining arrangement can also destroy useful capabilities embedded in the same historical pathway.

Historical reconstruction further helps distinguish lock-in from provisional stability. A stable arrangement can remain revisable when alternative capabilities and institutional pathways survive. Lock-in becomes practically stronger as alternatives are depleted, switching costs accumulate, or the field changes so that earlier options cease to be reachable. This connects historical interpretation directly to the evolving action-space architecture in Section 11.7 and the locally specified optimization and feasible-set representations in Section 11.12.

11.13.5 Contextual Interpretation

Contextual interpretation reconstructs what an action, category, observation, or institutional practice means within the practical relations in which it operates. The same formally described act can carry different practical meanings when its authority, audience, history, expectations, or relational position changes. Interpretation therefore contributes information that is not recoverable from syntax or behavior alone.

Definition 11.232 (Contextual interpretation). *Contextual interpretation* is the disciplined reconstruction of the situated meanings, reasons, expectations, categories, and practical understandings through which an action, statement, rule, observation, or relation becomes intelligible within a specified field.

Contextual interpretation is evidentially constrained. Participant accounts, observed practices, records, material arrangements, institutional rules, prior events, and alternative readings can support or challenge an interpretation. Disagreement among actors is itself relevant evidence because a practical field can contain multiple operative meanings. The analyst should therefore distinguish shared meaning, contested meaning, strategic representation, retrospective reinterpretation, and external analytical interpretation where these differences matter.

Interpretation can also affect the field. A public classification, official explanation, diagnostic label, or institutional narrative can be recognized by actors and become an epistemic event in the sense developed in Section 11.4. Once uptake changes expectations, rights, obligations, coordination, or self-understanding, interpretation has become coupled to transformation. Historical and interpretive analysis therefore contributes to the performative-observation architecture rather than standing outside it.

Definition 11.233 (Interpretive provenance record). An *interpretive provenance record* identifies the materials, positions, temporal context, alternative readings, unresolved ambiguities, and practical consequences associated with a materially important interpretation.

The record becomes especially useful when interpretive conclusions inform high-consequence action. It preserves the difference between what participants said, what institutions formally recorded, what the analyst inferred, and how later practical

events changed the interpretation.

11.13.6 Legal Interpretation

Legal interpretation enters practical analysis where authority, obligation, permission, standing, procedure, liability, rights, jurisdiction, or institutional competence materially shape the action space. Its practical object is broader than the text of a rule. Applicable sources, institutional practice, authoritative interpretation, factual classification, procedural posture, and temporal validity can jointly determine what a rule means for a particular practical situation.

Definition 11.234 (Legal-interpretive practical profile). A *legal-interpretive practical profile* records the relevant legal or rule-governed sources, interpretive authority, jurisdiction or institutional competence, material factual classifications, procedural conditions, contested interpretations, temporal status, and practical consequences for the action space.

This profile is methodological rather than a substitute for professional legal judgment. Its role within GR is to prevent a decision model from treating law as a static binary constraint when the practical operation of a rule depends on interpretation, institutional authority, exception, procedure, interaction among sources, or change through time. Where legal uncertainty is consequential, the uncertainty belongs inside the decision architecture rather than being hidden behind a fixed feasibility flag.

Legal categories can also be performative. Recognition of a subject under a legal status can change rights, obligations, eligibility, standing, institutional responsibilities, and available actions. An interpretive event can therefore transform the practical field. Conversely, a formal entitlement can remain weakly effective where institutional capacity, information, enforcement, or access is absent. Legal interpretation should consequently be connected to the relational and institutional diagnosis rather than treated as text retrieval alone.

Comparative use requires caution because legal meaning is strongly dependent on institutional setting, hierarchy of authority, temporal validity, and procedural context. Similar wording across systems does not establish equivalent practical operation. Conditions of transfer are addressed directly in Subsection 11.13.10.

11.13.7 Cultural Meaning

Cultural meaning concerns symbols, conventions, expectations, practices, identities, categories, and shared or contested forms of significance that mediate practical response. An intervention can be materially identical across two settings while producing different consequences because actors interpret its form, source, timing, symbolism, or relational implication differently. Cultural meaning can therefore affect uptake, refusal, trust, legitimacy, coordination, and the generation of later options.

Definition 11.235 (Cultural-meaning profile). A *cultural-meaning profile* reconstructs the symbols, conventions, classifications, identities, expectations, practical norms, and contested meanings that materially mediate how a practical object or intervention is interpreted and enacted within a specified field.

The profile should avoid converting culture into a homogeneous group attribute. Cultural fields can contain internal disagreement, cross-cutting identities, institutional variation, generational change, strategic use of symbols, and rapid transformation. A practical analysis therefore reconstructs the relevant meaning relations at the scale required by the decision rather than assuming uniformity from broad labels.

Meaning can itself change through intervention. New practices can become normalized; categories can acquire new symbolic associations; an institutional response can transform expectations; and repeated participation can generate a shared vocabulary that did not previously exist. Cultural analysis therefore concerns both inherited meanings and *meaning-generative effects* of praxis.

For decision methodology, the key contribution is often interpretive sensitivity. A technically efficient option can become practically weak if it produces distrust, symbolic exclusion, or category mismatch. Conversely, a modest material change can have substantial practical consequence when it alters recognition, legitimacy, or relational meaning. These consequences should be documented rather than silently translated into a generic preference parameter unless such a representation is locally justified.

11.13.8 Local Knowledge

Local knowledge is knowledge generated through situated participation in a practical field. It can concern operational routines, environmental conditions, informal institutions, timing, exception handling, social relations, tacit warning signals, resource constraints, or the practical meaning of categories. Its importance follows from differentiated epistemic position: actors located at different points in a relational field can have access to different aspects of the same practical configuration.

Definition 11.236 (Local practical knowledge). *Local practical knowledge* is situated knowledge acquired through participation, experience, observation, practice, or sustained relation within a specific practical field and whose warrant and scope depend materially on that situated access.

Local knowledge is neither automatically privileged nor automatically inferior to expert or formal knowledge. Its epistemic contribution depends on the object. Front-line actors can observe implementation failure before central indicators register it; affected subjects can identify burdens omitted from administrative categories; technical experts can identify mechanisms inaccessible to everyday observation; comparative analysts can detect patterns unavailable within one local field. Practical methodology should therefore construct interfaces among differentiated knowledge positions.

A *local-knowledge interface* records how situated claims enter wider decision processes, including translation, verification, aggregation where appropriate, protection against retaliation, feedback to contributors, and treatment of disagreement. Such interfaces are important because institutions can extract local knowledge without transferring interpretive authority or practical influence. The resulting record should preserve both the contribution and the relational conditions under which it was produced.

Local knowledge can also be time-sensitive. A practice that worked under one institutional regime can lose validity after infrastructure, law, ecology, technology, or social relations change. Versioning and provenance therefore apply to local knowledge as they do to formal models.

11.13.9 Narrative Understanding

Narrative understanding organizes events into temporally and causally intelligible accounts. In practical fields, narratives can connect origin, responsibility, injury, progress, decline, identity, expectation, and imagined futures. They influence which events are treated as significant, which actors receive agency, what consequences count as continuation or rupture, and which future actions appear plausible or legitimate.

Definition 11.237 (Practical narrative configuration). A *practical narrative configuration* is a situated organization of actors, events, temporal relations, causal or moral significance, and anticipated futures through which a practical field becomes intelligible to one or more positions.

Narrative analysis should distinguish a narrative from the history it organizes. Coherent narrative form can omit events, compress uncertainty, assign agency selectively, or stabilize a particular causal interpretation. Competing narratives can therefore be compared against records, sequence, institutional evidence, and alternative accounts. Their practical importance can remain high even when their historical adequacy differs, because actors can organize action around narratives they treat as meaningful.

Narratives are also generative. A narrative of inevitable decline can alter investment and coordination; a narrative of institutional recovery can support cooperation; an official account of failure can allocate responsibility and define what reforms become conceivable. Once circulated and taken up, a narrative can function as an epistemic event that changes the field it describes.

Definition 11.238 (Narrative consequence profile). A *narrative consequence profile* records the practical positions that produce or receive a narrative, the events and relations it foregrounds or omits, its evidential support and contested elements, and the ways its uptake can alter expectations, responsibility, coordination, recognition, or future action spaces.

Narrative understanding therefore interfaces directly with scenario construction. Scenarios in Section 11.8 can be formally generated, narratively communicated, or both. The narrative form through which a modeled history is presented can affect how actors interpret its plausibility and urgency. Practical use should preserve the distinction between model structure and narrative presentation while analyzing their interaction.

11.13.10 Conditions of Interpretive Transfer

Historical and interpretive conclusions often need to travel across cases, institutions, times, languages, or practical domains. Transfer is possible when the analyst can identify which relations, meanings, mechanisms, or institutional conditions remain

sufficiently corresponding for the earlier interpretation to retain practical relevance. The relevant object is therefore conditional portability rather than presumed universality.

Definition 11.239 (Interpretive transfer). *Interpretive transfer* is the disciplined use of a historically or contextually grounded interpretation in a different practical setting through explicit reconstruction of correspondence, transformation, remainder, and conditions of validity.

A transfer analysis should compare the source and target settings along dimensions that matter to the claim. These can include category meaning, institutional authority, actor position, temporal structure, legal setting, cultural convention, material infrastructure, capability, path dependence, language, and observation regime. Exact similarity is unnecessary. The objective is to establish whether the relation supporting the interpretation persists, has transformed, or has disappeared.

Definition 11.240 (Interpretive transfer profile). An *interpretive transfer profile* records the source context, target context, proposed correspondence, transformed elements, unresolved differences, material remainders, evidential basis, and conditions under which the transferred interpretation should be revised or withdrawn.

The concept of a *transfer remainder* is especially important. Some meanings, institutional relations, historical burdens, or category distinctions can resist translation into the target setting. Preserving that remainder is preferable to forcing apparent equivalence. A transfer can therefore be partial while remaining useful.

Transfer also works in the opposite direction. A target setting can reveal that the source interpretation was oversimplified, because the attempt at translation exposes an assumption previously treated as background. Comparative practical analysis can consequently revise both source and target understanding. This is consistent with the wider GR commitment to methodological recursivity: application across settings can itself become an epistemic event that changes the interpretation being transferred.

Proposition 11.241 (Historically situated practical interpretation). *Historical and interpretive practical analysis supports consequential praxis most strongly when temporal formation, situated meaning, evidential provenance, alternative interpretations, and transfer conditions remain explicit enough for the interpretation to be contested, revised, and combined with other methodological representations.*

The practical consequence of Proposition 11.241 is methodological complementarity. Historical reconstruction can revise a supposedly fixed feasible set; legal interpretation can alter institutional admissibility; local knowledge can reveal implementation mechanisms; narrative analysis can identify performative meaning; and cultural interpretation can disclose why formally similar interventions generate different responses. Formal models can in turn test internal consistency, expose hidden assumptions, organize comparison, and show where an interpretive account implies consequences that require further evidence.

Historical and interpretive analysis also clarifies the next methodological problem. Practical meaning and knowledge are distributed across affected subjects, institutions, experts, representatives, and other participants. Methods are therefore required for deciding whose knowledge enters a practical process, through which representation, under what conditions of voice and authority, and with what capac-

ity to contest the resulting decision architecture. Section 296 consequently turns to participatory decision methods.

11.14 Participatory Decision Methods

Section 11.13 established that practical knowledge, meaning, and historical understanding are distributed across differently situated subjects, institutions, experts, representatives, and local participants. The present section develops the methodological architecture required when consequential decisions must draw on that distributed knowledge while also allocating voice, representation, authority, burden, and contestability. Its role within Chapter 11 is to translate the domain-general participation architecture developed in Chapter 10 into operational decision methods. Its objective is to specify how stakeholders and affected subjects are identified, how deliberation and participatory mapping are organized, how co-design differs from consultation, how representation and voice are governed, how participation can function as an epistemic event, how contestability is preserved, and how unequal participation is diagnosed and mitigated. The method is relational and procedural. Participation is treated as a sequence of practically consequential interfaces rather than as a binary property of whether a process included participants.

Participatory decision methods enter applied praxis because practical knowledge and practical authority are rarely concentrated in the same position. A central institution can possess formal decision rights while lacking detailed knowledge of implementation conditions. Technical specialists can possess mechanism knowledge while having limited access to situated burdens. Affected subjects can possess direct knowledge of consequences while lacking recognized categories through which that knowledge can enter a formal process. Representatives can coordinate collective expression while remaining imperfectly connected to the positions they represent. Participatory methodology is therefore concerned with the architecture through which these differentiated positions become visible, communicable, comparable, and practically consequential.

Participation should also be understood as potentially generative. A participatory process can produce new information, new categories, new relationships, new trust or distrust, new collective capabilities, and new action possibilities. It can also alter expectations, redistribute authority, create procedural dependence, or stabilize particular representations of a problem. Participation is therefore not merely an input channel attached to a decision that was otherwise already constituted. In some settings it changes the practical field within which the decision itself is defined.

Definition 11.242 (Participatory decision method). *A participatory decision method is a specified and revisable procedure through which affected subjects, stakeholders, representatives, experts, institutions, or other practically relevant positions contribute knowledge, interpretation, judgment, proposal, authorization, implementation, monitoring, contestation, or revision to a consequential decision process.*

Definition 11.243 (Participation-method architecture). *A participation-method architecture records the positions included in a participatory process, the practical functions assigned to them, the stages at which they enter, the forms through which they*

Table 11.14: Methodological components of participatory decision-making.

Component	Methodological object	Primary contribution	Characteristic concern
Stakeholder identification	Positions with consequential relations to praxis	Maps knowledge, authority, implementation, dependence, responsibility, and affectedness	Broad lists can obscure differences in standing and practical function
Affected subjects	Positions materially altered by the trajectory	Reveals burdens, benefits, risks, option changes, and situated consequences	Some affected positions are weakly visible or unable to participate directly
Deliberation	Structured exchange of reasons and interpretations	Tests claims, exposes disagreement, revises framing, and develops provisional orientation	Procedure, agenda, language, power, and time can shape what becomes discussable
Participatory mapping	Joint construction of relational representations	Adds local knowledge, alternative boundaries, hidden relations, and contested categories	A map can stabilize one representation and exclude relations that resist the chosen form
Co-design	Shared generation and revision of alternatives	Expands the action space and aligns design with situated capabilities and constraints	Nominal collaboration can preserve externally fixed goals or decision rights
Representation	Relations through which some positions speak or act for others	Extends participation where direct entry is difficult and supports continuity and aggregation	Mandate, feedback, internal diversity, and representational distance require governance
Voice	Pathways for claims, warnings, proposals, and dissent	Makes situated knowledge and judgment practically receivable	Expression can remain symbolic when uptake, protection, or response pathways are weak
Epistemic participation	Participation as knowledge-generating and field-transforming event	Generates evidence, categories, relations, and revised action possibilities	Observation and participation can change the field whose properties are being inferred
Contestability	Procedures for challenge, review, and reopening	Supports correction, alternative evidence, reason-giving, and revision	Contestation must be usable, protected, timely, and connected to consequences
Unequal participation	Distribution of participation capacity and burden	Diagnoses differential access, cost, risk, influence, and persistence	Equal invitation can coexist with unequal effective participation and unequal exposure

contribute, the authority attached to those contributions, the burdens and protections associated with participation, and the pathways through which disagreement can alter or reopen the process.

Table 11.14 summarizes the ten methodological components developed below. The table separates roles that are often compressed into a single vocabulary of stakeholder engagement. Identification, affectedness analysis, deliberation, mapping, design, representation, voice, epistemic participation, contestability, and participation equality perform different functions. A process can be strong in one and weak in another. Methodological evaluation should therefore reconstruct the complete participation architecture rather than infer quality from the number of meetings, participants, comments, or represented organizations.

11.14.1 Stakeholder Identification

Stakeholder identification determines which positions enter the initial participatory frame and why. Its methodological role is not to create a flat inventory of everyone who might have an interest. It is to reconstruct materially relevant relations to the practical object. These relations can include affectedness, authority, knowledge, implementation capacity, dependency, resource control, maintenance responsibility, legal standing, representational role, or capacity to alter the trajectory through support, refusal, adaptation, or exit.

Definition 11.244 (Stakeholder identification profile). A *stakeholder identification profile* records each provisionally identified position, the relation through which it becomes practically relevant, the stage and horizon of that relevance, the form of knowledge or authority it may contribute, and the conditions under which its status should be revised.

The term *stakeholder* should therefore remain role-sensitive. A position that bears substantial risk differs from a position that supplies technical expertise. A regulator differs from a service provider. A group whose future options can be foreclosed differs from an actor with a commercial interest in implementation. Treating these relations as interchangeable can convert participation into a negotiation among recognized organizations while leaving consequence-bearing positions weakly represented.

Identification should also be recursive. Practical diagnosis, historical reconstruction, scenario analysis, monitoring, or participation itself can reveal positions that were omitted initially. A new relation can emerge during implementation. A group can become affected only after an institution changes its procedures. A future maintenance burden can create a stakeholder relation that was absent at the moment of authorization. Stakeholder identification is therefore a versioned practical map rather than a one-time administrative list.

The method can proceed through several complementary routes. Institutional records can identify formally recognized actors. Relation mapping can reveal dependency and authority. Historical analysis can reveal positions whose present exclusion results from earlier classifications. Local knowledge can disclose informal actors or intermediaries. Scenario construction can identify positions exposed only under adverse or long-horizon histories. These routes need not converge immediately. Their disagreement can itself indicate uncertainty about the practical boundary.

A stakeholder method should also distinguish practical relevance from representational convenience. Highly organized actors are easier to contact than dispersed or weakly institutionalized positions. Administrative visibility can therefore bias identification toward actors already legible to the institution. The method should record this possibility through a *stakeholder visibility gap*: a difference between practical relevance and the capacity of the current process to recognize and engage the relevant position.

Definition 11.245 (Stakeholder visibility gap). A *stakeholder visibility gap* is a material difference between a position's practical relevance to a decision trajectory and the degree to which that position is recognized, represented, or reachable within the

current participation architecture.

Stakeholder identification consequently prepares, but does not settle, questions of standing. Inclusion in a stakeholder map does not automatically imply equal decision authority. Different practical relations can justify different forms of participation. The methodological task is first to make those relations explicit enough that later allocation of participation and authority can be examined rather than silently inherited from institutional convenience.

11.14.2 Affected Subjects

Affected-subject analysis gives methodological priority to positions whose conditions are materially altered by the practical trajectory. Chapter 10 defined affected subjects broadly in relation to capabilities, burdens, benefits, risks, rights, dependencies, environments, and future options. The present subsection operationalizes that category by asking how affectedness is identified prospectively, observed during implementation, and revised when previously unseen consequences emerge.

Definition 11.246 (Affected-subject tracing). *Affected-subject tracing* is a participatory and analytical method for identifying the positions whose conditions can be materially altered by an intervention, non-action, institutional arrangement, or evolving practical history, together with the pathways through which those effects arise.

Affected-subject tracing can begin from the anticipated consequence structure of the decision. Direct recipients are only one subset. The method should also examine relational propagation: suppliers, caregivers, neighboring institutions, maintenance actors, dependent populations, ecological relations, later users, or other positions can inherit consequences through channels not captured by the initial target definition. Scenario analysis can help identify such positions before commitment, while monitoring can reveal them afterward.

The method should preserve multiple dimensions of affectedness rather than using one magnitude score by default. Duration, reversibility, voluntariness, dependence, substitutability, exposure, recovery capacity, option loss, and distribution can all change the practical significance of an effect. A modest but irreversible loss of access can matter differently from a larger temporary inconvenience. A benefit that generates long-term dependence can require different analysis from a benefit that expands independent capability.

Direct participation can itself be difficult or impossible for some affected subjects. Future subjects cannot attend present deliberation. Some subjects may face language, disability, safety, mobility, legal-status, time, or economic barriers. Some practical objects include non-human living systems or diffuse ecological relations for which direct voice is unavailable. Under these conditions, affectedness should not disappear merely because conventional participation is impossible. Representation, guardianship, scenario analysis, ecological evidence, legal duties, institutional trusteeship, or other methods can provide partial access while making the absence of direct feedback explicit.

Affectedness can also be revealed through participation itself. A participant may describe a burden that the initial diagnostic categories did not contain. Recognition

of that burden can become an epistemic event that revises the problem representation, consequence map, or affected-subject boundary. The method should preserve a route from such disclosure to formal revision rather than treating it as anecdotal commentary outside the analytical frame.

Definition 11.247 (Affectedness revision trigger). An *affectedness revision trigger* is an observation, testimony, consequence, model result, or practical event that provides material reason to revise which positions are treated as affected, how affectedness is represented, or how participation and protection are allocated.

The resulting affected-subject map should be linked to later participation methods. Deliberation can test interpretations of consequence. Participatory mapping can reveal relational propagation. Co-design can alter how burdens are distributed. Representation and voice determine how affectedness enters collective judgment. Contestability provides a route when the formal process continues to misrecognize an affected position. Affected-subject analysis therefore functions as an organizing relation across the whole participatory architecture.

11.14.3 Deliberation

Deliberation is a structured method for exchanging reasons, interpretations, evidence, values, objections, and proposals under conditions where no single position possesses complete practical knowledge or uncontested authority. Its methodological contribution is broader than preference aggregation. Deliberation can reveal hidden assumptions, distinguish factual disagreement from value disagreement, expose divergent interpretations of risk, generate new alternatives, and revise the language through which the practical problem is described.

Definition 11.248 (Practical deliberation protocol). A *practical deliberation protocol* specifies the participants, agenda formation process, information access, forms of contribution, sequencing of discussion, facilitation and translation arrangements, decision relation, dissent recording, protection conditions, and revision pathways through which structured practical reasoning occurs.

The protocol matters because deliberation is itself an intervention into the field. Agenda order can shape salience. Technical framing can privilege some forms of knowledge. Time limits can favor participants already familiar with institutional language. Public settings can suppress contributions carrying social or professional risk. Early statements by high-status actors can change later expression. A deliberative method should therefore record relevant procedural choices rather than treating the conversation as an unstructured source of preferences.

Deliberation can serve different practical functions. It can be exploratory, seeking to identify concerns and categories. It can be interpretive, testing competing understandings. It can be generative, producing alternatives. It can be comparative, examining consequences among options. It can be authorizing, contributing to a collective commitment. It can be evaluative or revisional after implementation. These functions should be distinguished because the appropriate participant composition, information requirements, and decision consequences differ across them.

Disagreement should remain visible. A deliberative process need not convert plu-

ral values or interpretations into consensus. Forced convergence can erase material uncertainty or minority knowledge. The method should instead distinguish areas of convergence, structured disagreement, unresolved uncertainty, protected objections, and questions requiring additional inquiry. A *deliberation record* can preserve these distinctions together with the reasons offered for provisional closure.

Definition 11.249 (Deliberation record). A *deliberation record* documents the materially relevant claims, reasons, evidence, disagreements, alternative formulations, proposed options, unresolved questions, and changes of position that emerged through a deliberative process, together with their relation to subsequent decision or revision.

Deliberation can also generate collective capability. Participants may develop a shared vocabulary, new trust relations, improved understanding of institutional constraints, or new capacity for coordinated action. Conversely, poorly governed deliberation can generate distrust, exhaustion, strategic polarization, or the impression of participation without influence. The methodological object is therefore both the content generated through discussion and the relational consequences of the deliberative process itself.

11.14.4 Participatory Mapping

Participatory mapping combines relational representation with situated knowledge. Participants contribute to the construction, correction, or interpretation of maps of actors, relations, resources, constraints, capacities, risks, histories, institutions, places, or action possibilities. The map can be spatial, network-based, processual, temporal, categorical, narrative, or hybrid. Its defining feature is that the represented field is constructed through structured contribution from positions that possess differentiated access to it.

Definition 11.250 (Participatory practical map). A *participatory practical map* is a revisable representation of a consequential field whose objects, relations, boundaries, labels, or interpretations are constructed or corrected through contributions from multiple situated positions.

Participatory mapping can reveal relations that centralized administrative data omit. Front-line participants can identify informal dependencies. Affected subjects can show where a formally available service becomes inaccessible. Local actors can identify timing, maintenance, trust, or mobility relations absent from a conventional network model. Historical participants can add events that explain present categories. Experts can contribute mechanism structure. The method therefore creates an interface among forms of access rather than presuming that one source contains the complete map.

Mapping should also record disagreement. Participants can differ over whether a relation exists, how strong it is, what it means, where a boundary lies, or which historical event matters. A single finalized map can conceal this disagreement. Where relevant, the method can preserve layered maps, alternative labels, uncertainty markers, provenance, or parallel representations. The objective is not graphical consensus for its own sake but a decision-relevant representation whose provenance and contestation remain visible.

The mapping process can itself become performative. Naming a relation can make it institutionally visible. Representing an informal actor can alter recognition or bargaining position. Drawing a boundary can create a category that later structures eligibility or responsibility. Mapping therefore belongs directly to the epistemic-event architecture of Section 11.4. A participatory practical map should record when the act of representation materially changes the field it depicts.

Definition 11.251 (Map provenance layer). A *map provenance layer* records which positions contributed particular objects, relations, labels, boundaries, confidence judgments, disagreements, or revisions to a participatory practical map and how those contributions were transformed during synthesis.

Participatory maps can interface with formal models without being reduced to them. A relational map can inform a network representation. A temporal event map can inform a partial-order or 2-complex model. A map of constraints and capacities can inform scenario construction. Yet the translation should preserve remainders where participants' categories, meanings, or uncertainties do not have a justified formal counterpart. This keeps participatory mapping consistent with the model-plurality discipline developed throughout Chapter 11.

11.14.5 Co-Design

Co-design concerns participatory generation and revision of practical alternatives. Its methodological significance follows directly from the evolving-action-space architecture of Section 11.7. If the existing action menu is historically produced and incomplete, participation need not be limited to evaluating alternatives defined elsewhere. Participants can contribute to generating new interventions, institutional arrangements, sequencing strategies, safeguards, interfaces, monitoring practices, or mechanisms of implementation.

Definition 11.252 (Practical co-design). *Practical co-design* is a structured participatory method through which multiple practically relevant positions jointly generate, specify, test, or revise elements of an action, intervention, institutional arrangement, or adaptive pathway.

The degree of co-design can vary. Participants can shape problem formulation, goals, design parameters, service interfaces, implementation rules, monitoring, or revision conditions. A process should therefore state which design objects are genuinely open. Inviting participants to choose colors, wording, or minor implementation details while goals, architecture, resource allocation, and authority remain fixed is methodologically different from allowing participants to reshape the intervention structure itself.

Co-design can generate options through recombination of differentiated knowledge. Technical actors can identify physical feasibility. Local actors can identify practical workarounds. Affected subjects can identify burdens or opportunities. Institutional actors can identify legal and procedural pathways. The resulting alternative can therefore be absent from any participant's initial option set. This is a direct example of participation generating the action space rather than merely evaluating it.

The method should also preserve design provenance. When an alternative

emerges through a multi-actor process, later evaluation should be able to reconstruct which constraints, values, observations, and trade-offs shaped it. Otherwise the final design can appear as a technically given object, and the practical reasons for its form can disappear from institutional memory.

Definition 11.253 (Co-design provenance record). A *co-design provenance record* documents the practical positions, contributions, constraints, design changes, unresolved disagreements, and decision rights through which a co-designed alternative was generated and revised.

Co-design also changes participants. Repeated design work can build capability, shared vocabulary, trust, and implementation ownership. It can also consume time, create dependency on facilitation, expose internal disagreements, or shift responsibility toward participants who lack corresponding authority or resources. The method should therefore evaluate the generative consequences of the design process itself alongside the qualities of the resulting intervention.

11.14.6 Representation

Representation becomes necessary whenever affected or relevant positions cannot participate directly at every stage or scale. Participatory decision methodology should therefore specify how representatives are selected or recognized, what they are authorized to do, how they remain connected to represented positions, and how representational claims can be corrected. Representation is a relational method of extending practical presence, not a simple substitution of one actor for another.

Definition 11.254 (Representational method profile). A *representational method profile* records the represented positions, representative positions, basis of mandate, scope and duration of authorization, channels of feedback, internal diversity, accountability conditions, and mechanisms for revision or replacement.

Representation can arise through election, delegation, appointment, professional role, guardianship, legal standing, association, expertise, institutional mandate, or informal recognition. These forms carry different justificatory structures. A representative selected by a membership organization differs from an expert asked to infer the interests of future subjects. A community leader differs from an administrative category that claims to stand for a population. The method should document these differences rather than place them under one undifferentiated heading.

Representational adequacy is also stage-specific. A representative who can articulate broad concerns may be poorly positioned to evaluate technical implementation. A technical representative may possess strong domain knowledge while weakly reflecting internal value pluralism. Multiple representatives or layered representation can sometimes preserve differentiated functions more effectively than seeking one spokesperson for a heterogeneous position.

The method should monitor *representational drift*: divergence between the practical claims, priorities, or conditions of represented positions and the claims advanced by a representative over time. Drift can arise from changing circumstances, information asymmetry, professionalization, institutional incentives, weak feedback, or internal disagreement among represented subjects.

Definition 11.255 (Representational drift). *Representational drift* is a material divergence over time between the practical positions attributed to represented subjects and the positions articulated or enacted by those acting on their behalf, relative to the authorized representational relation.

Direct feedback can reduce drift where it is possible. Where represented subjects cannot provide feedback directly, the architecture should preserve alternative safeguards: plural representation, trusteeship duties, transparent assumptions, external review, scenario analysis, contestability, or periodic reconsideration of the representational basis. The objective is not perfect identity between representative and represented position, but a traceable and revisable relation whose limits remain visible.

11.14.7 Voice

Voice concerns the methodological pathway through which knowledge, experience, judgment, objection, proposal, warning, or dissent becomes practically receivable. Chapter 10 distinguished voice from participation and from influence. The applied methodological task is therefore to design and evaluate the chain from expression to reception and response rather than counting opportunities to speak.

Definition 11.256 (Voice-method pathway). A *voice-method pathway* is the organized sequence through which a participant or represented position can formulate a contribution, transmit it through an accessible channel, obtain translation or protection where needed, have it received by relevant decision positions, and connect it to a documented response, inquiry, or revision process.

Different forms of knowledge require different voice interfaces. Quantitative evidence can enter through formal reports. Operational knowledge can enter through incident logs or structured interviews. Lived experience can require narrative formats. Dissent can require confidential or protected channels. Local warnings can require rapid escalation rather than periodic consultation. A single participation interface can therefore systematically privilege the forms of expression it was designed to receive.

Voice methods should distinguish *expression capacity*, *transmission capacity*, *reception capacity*, and *response capacity*. Weakness in any one dimension can sever the pathway. A technically open comment period can still produce weak voice if submissions are not read by relevant actors, if institutional categories render them unintelligible, if retaliation is possible, or if no process exists for responding to material objections.

Voice also interacts with epistemic status. A participant's statement can be testimony, observation, interpretation, value judgment, warning, proposal, or strategic claim. The method should preserve these distinctions without requiring every contribution to imitate expert evidence. Different contributions can carry different inferential roles. A lived account can reveal an unrecognized burden without independently establishing a general causal mechanism. A technical model can estimate a mechanism without representing the practical meaning of its consequences.

A *voice uptake record* can preserve this relation between contribution and institutional response.

Definition 11.257 (Voice uptake record). A *voice uptake record* documents a materially relevant contribution, the position from which it originated, its practical and epistemic type, the pathway through which it was considered, the response or resulting inquiry, and any consequent change to the decision architecture.

This record helps distinguish reasoned non-adoption from symbolic consultation. A contribution need not determine the final decision to possess effective voice. It should, however, have a plausible and traceable route to consideration, response, investigation, or revision where its relevance warrants such treatment.

11.14.8 Participation as Epistemic Event

The revised GR epistemic architecture gives participation a stronger methodological role than information elicitation. A participatory encounter can generate an epistemic event when it changes how the practical field is observed, categorized, interpreted, or institutionally recognized. If that event is taken up by actors or institutions, it can also become performatively coupled to transformations of the field itself.

Definition 11.258 (Participatory epistemic event). A *participatory epistemic event* is an event arising through participatory praxis that materially changes a practical representation, category, evidential relation, recognized subject position, model, action space, or other epistemic condition relevant to subsequent decision or intervention.

A participatory epistemic event can take many forms. Testimony can reveal a previously unrecognized burden. Deliberation can distinguish two mechanisms that were previously conflated. Participatory mapping can reveal an informal dependency. Co-design can generate an alternative absent from the prior feasible set. Recognition of a group as affected can change standing or institutional obligations. A local warning can cause a model to be revised. These events do more than add another data point to an unchanged analysis.

The methodological challenge is to preserve the distinction between *readout* and *transformation*. Participation can first produce a representation: a map, statement, classification, or revised model. Its institutional uptake can then change the field by redistributing attention, authority, resources, rights, expectations, or action possibilities. The participation record should document both moments where they differ.

Definition 11.259 (Participatory epistemic coupling record). A *participatory epistemic coupling record* identifies a participatory event, the representation or knowledge change it produced, the mechanism through which that change entered practical uptake, and the resulting transformation, if any, of relations, institutions, subjects, capacities, constraints, models, or action spaces.

This structure also clarifies why participation can change history weights or transition potentials in model-specific form. A newly recognized constraint can reduce the accessibility of one proposed trajectory. Formation of trust can increase the practical reachability of a cooperative path. A new legal or institutional recognition can generate a branch that did not previously belong to the reachable action space. In a 2-complex or partially ordered representation, the participatory event can become a new vertex whose relational consequences alter later admissible extensions. These are optional computational realizations of a broader methodological point: partici-

pation can change the conditions under which later histories unfold.

The same generative capacity can create risk. Participation can stabilize an inaccurate category, expose participants to retaliation, create expectations that cannot be met, or reorganize bargaining relations in unintended ways. Participatory methods should therefore be evaluated as interventions with consequences, not only as neutral channels for collecting information.

Proposition 11.260 (Participation and practical evolution). *When a participatory process materially changes practical representations, recognized positions, relations, capacities, institutions, or reachable actions, participation belongs to the generative history of the decision field and should be documented as part of the intervention architecture rather than treated solely as prior consultation.*

11.14.9 Contestability

Contestability provides a methodological route for challenging practical representations, evidence, procedures, criteria, authority, implementation, or consequences after an initial participation process has produced provisional closure. It is therefore distinct from initial participation. A subject can have been included in deliberation and still require a later pathway to challenge the resulting decision when new evidence, changed conditions, or unaddressed disagreement emerges.

Definition 11.261 (Participatory contestability architecture). *A participatory contestability architecture specifies the practical objects that can be challenged, the positions with standing to initiate challenge, the channels and evidentiary forms through which challenge can enter, the protection and review conditions attached to it, and the possible consequences for explanation, correction, remedy, revision, suspension, or reopening.*

Contestability should be proportionate to the practical object. A technical parameter correction can require a different route from a challenge to the legitimacy of the problem formulation or the authority of the decision body. The architecture can therefore contain multiple levels: local correction, formal review, escalation, independent appeal, public challenge, or reopening of deliberation. Each level should specify what can change and who can authorize the change.

Usability matters. A formal appeal right can be practically weak if the process is costly, slow, inaccessible, risky, procedurally opaque, or disconnected from any power to alter the decision. Contestability should therefore be evaluated through an *effective contestability profile* containing access, cost, timeliness, protection, independence, reason-giving, remedy, and capacity to reopen materially relevant questions.

Contestability also supports epistemic correction. A challenge can reveal omitted evidence, a model failure, misclassification, changing affectedness, unanticipated harm, or representational drift. The contestation itself can therefore become an epistemic event. The method should preserve a trace from challenge to response so that institutional learning is possible even where the original decision remains in force.

A participation process organized around consensus can make contestability especially important. Consensus at one moment does not eliminate later disagreement or new consequences. Likewise, minority positions recorded during deliberation can

become relevant if later events support their concerns. The contestability architecture should therefore connect to dissent records, monitoring, provenance, and the reopening conditions developed in Chapter 10.

Proposition 11.262 (Contestability and provisional closure). *Participatory decision methods support responsible provisional closure most strongly when materially relevant challenge can enter a protected, intelligible, and consequence-bearing review pathway after initial participation has ended.*

11.14.10 Unequal Participation

Participation capacity is distributed unevenly. Time, money, safety, language, literacy, technical expertise, institutional familiarity, social status, mobility, digital access, legal standing, organizational support, confidence, and prior experience can all affect whether a formally available participatory opportunity becomes practically usable. Methodological analysis should therefore distinguish equal invitation from equal effective capacity to participate.

Definition 11.263 (Participation-capacity profile). *A participation-capacity profile records the resources, capabilities, protections, access conditions, interpretive support, time, persistence, and institutional relations that affect a position's practical ability to enter, remain in, influence, and withdraw from a participatory process.*

Unequal participation can operate through several stages. Some positions are omitted before the process begins. Some can attend but cannot contribute in the dominant language or technical form. Some can contribute but possess little uptake. Some can influence one meeting but cannot sustain participation across a long process. Some bear substantial opportunity costs or risks for participation while others participate as part of paid professional roles. Some can threaten exit or mobilize external power while others cannot. These differences should not be collapsed into a single attendance statistic.

The method should therefore include a *participation burden profile*. Relevant burdens can include time, travel, care responsibilities, disclosure, translation effort, reputational or employment risk, exposure of sensitive knowledge, emotional labor, technical preparation, and repeated procedural engagement. Compensation, accessibility, scheduling, translation, confidentiality, childcare, technical assistance, protected channels, or other supports can alter these burdens, although no single support eliminates structural inequality by itself.

Definition 11.264 (Participation burden profile). *A participation burden profile records the material, temporal, cognitive, social, emotional, legal, informational, and opportunity costs that different positions bear in order to enter and remain within a participatory process.*

Unequal influence also requires separate analysis. A highly resourced actor can dominate agenda-setting without speaking more often. Technical expertise can shape the categories through which other contributions are interpreted. Institutional actors can control which proposals are considered feasible. Facilitators can influence sequencing and synthesis. Representatives can monopolize communication with decision-makers. *A participation influence profile* can therefore map practical

leverage across stages rather than infer influence from visibility alone.

Corrective design should be relational rather than mechanical. Equal speaking time can be useful in some settings and counterproductive in others. Weighted representation, separate deliberative spaces, protected minority reports, capacity-building, compensation, independent facilitation, or staged processes can sometimes improve effective participation. Their appropriateness depends on the relevant asymmetry and practical object. Methodological transparency requires documenting why a particular correction was chosen and what inequalities remain unresolved.

Unequal participation also creates a justice problem that cannot be solved by procedural inclusion alone. A process can become more participatory while transferring substantial burdens of knowledge production, legitimacy, or implementation to less powerful subjects. Participation should not become a mechanism through which institutions externalize responsibility onto those already exposed to consequences. The architecture should preserve the distinction between contributing to a decision and acquiring responsibility for institutional capacities one does not control.

Definition 11.265 (Participation equity remainder). *A participation equity remainder records material inequalities of access, burden, influence, representation, protection, or response capacity that remain after the participatory method has applied its feasible corrective measures.*

Preserving this remainder supports later accountability and revision. A participatory process can be the best available architecture under present constraints while still carrying unresolved inequalities. Recording them is preferable to representing procedural completion as equal agency.

Proposition 11.266 (Participatory method adequacy). *A participatory decision method is practically stronger when it makes relevant positions visible, preserves differentiated epistemic contributions, connects voice to uptake, distinguishes participation from authority, records representational and participation inequalities, treats participation as potentially generative, and maintains usable pathways for contestation and revision.*

Proposition 11.266 locates participation within the wider decision architecture developed in this chapter. Participation can revise diagnosis, goals, models, action spaces, scenarios, criteria, and institutional arrangements. It can also generate new practical relations and therefore change which interventions become feasible or legitimate. The next methodological question concerns where purposive intervention should be directed once these epistemic, participatory, and relational structures have been reconstructed. Section 297 therefore turns to intervention target selection across state variables, relations, historical-relational subjects, structures, constraints, capacities, institutions, observation regimes, fields, generative conditions, rules, and history or transition potentials.

11.15 Intervention Target Selection

Sections 11.2–11.14 developed practical diagnosis, goal and criterion specification, epistemic-event architecture, decision analysis, scenario construction, robustness, adaptation, optimization, formal and interpretive models, and participatory meth-

ods. The present section turns from reconstruction and comparison toward the methodological problem of *where* purposive intervention is directed. Its role within Chapter 11 is to distinguish target selection from the later questions of timing, scale, intervention depth, and mechanism design. Its objective is to provide a layered target architecture spanning state variables, relations, historical-relational subjects and entities, structures, constraints, capacities, institutions, observation and representation regimes, fields, generative conditions, rule-level objects, and history or transition potentials. The method is relational, historical, and model-plural: a target is specified relative to a practical diagnosis and a representation of the field, while target selection remains revisable when epistemic or practical events disclose that the intervention is acting on a different object from the one initially intended.

An intervention target is not simply the variable that a decision-maker wishes to change. Practical configurations can be transformed at several analytically distinct levels. A program can seek to alter an observable state while leaving the relations generating that state largely unchanged. It can alter a relation without changing the institutional rule through which the relation is reproduced. It can expand a capability while leaving the surrounding constraint configuration intact. It can change a classification or observation regime and thereby transform which subjects become visible, which actions become institutionally available, and which future histories receive practical support. It can act on a generative rule rather than on a present output. It can also alter the relative accessibility of future histories without determining one unique future state. Target selection therefore concerns the practical object to which intervention is addressed and the consequences of choosing one target layer rather than another.

Definition 11.267 (Intervention target). An *intervention target* is a provisionally specified object, relation, configuration, process, condition, rule, representation, or history-generating feature toward which purposive practical transformation, preservation, activation, inhibition, or protection is directed.

Definition 11.268 (Target architecture). A *target architecture* records the selected intervention targets, their analytical levels, relations among targets, representation and measurement assumptions, expected generative relevance, affected positions, uncertainty, dependencies, and conditions under which the target specification should be revised.

Target selection should remain distinct from four adjacent methodological decisions. *Mechanism* concerns how an intervention is expected to alter the target or the field connected to it. *Depth* concerns how far into the generative architecture the intervention reaches. *Scale* concerns the spatial, relational, institutional, or historical resolution at which intervention is organized. *Timing and sequencing* concern when and in what order interventions occur. A relation can be the target at several different scales; an institution can be modified superficially or deeply; the same capacity target can be approached through multiple mechanisms; and an appropriate target can still fail if engaged at the wrong time. Sections 300–301 therefore develop these design problems separately after the target architecture has been established.

Table 11.15 summarizes the layered target architecture developed below. The layers are analytically distinguishable but practically coupled. An intervention aimed at a state variable can change relations; an institutional reform can alter observation

Table 11.15: Layered architecture of intervention targets in application-dominant praxis.

Target layer	Practical object	Characteristic intervention question	Characteristic risk
State variables	Observable or modeled configuration variables	Which present condition should be shifted, stabilized, bounded, or restored?	State improvement can leave the generating architecture unchanged
Relations	Dependencies, flows, authority, trust, communication, care, exposure	Which relation should be created, weakened, strengthened, redirected, or protected?	Pairwise targeting can miss higher-order or historical relational structure
Subjects	Historical-relational configurations possessing continuity and agency	Which capacities, standings, internal relations, or historical conditions of a subject are implicated?	Point-agent representations can erase constitutive history and internal structure
Structures	Recurrent topology, organization, hierarchy, or pattern	Which durable configuration reproduces the practical trajectory?	Structural labels can become vague if mechanisms and boundaries remain unspecified
Constraints	Conditions restricting reachability or admissibility	Which constraint should be relaxed, transformed, preserved, or made explicit?	Removing a constraint can also remove protection, coordination, or constitutive order
Capacities	Effective abilities to sense, decide, act, maintain, learn, repair, or revise	Which capability should be generated, sustained, distributed, or regenerated?	Temporary resource injection can be mistaken for durable capacity
Institutions	Mandates, rules, roles, routines, memory, authority, and interfaces	Which institutional arrangement should be redesigned, strengthened, or reconstituted?	Formal redesign can diverge from enacted institutional practice
Observation regimes	Categories, indicators, records, classifications, models, and visibility rules	Which epistemic interface should be changed so that the field is observed differently?	Observation can become performative, exclusionary, or strategically manipulated
Fields	Distributed conditions affecting local possibilities and interactions	Which distributed influence, opportunity, exposure, or constraint pattern should change?	Field abstractions can obscure local heterogeneity and boundary dependence
Generative conditions	Conditions enabling or suppressing later valued generation	Which conditions shape the production of future capacities, relations, and possibilities?	Generativity can be expanded for some positions while narrowed for others
Rules	Transformation laws, permissions, composition rules, or update regimes	Which rule governing evolution or admissible transformation should be revised?	Rule change can propagate widely and generate difficult-to-reverse consequences
History potentials	Weights, accessibility, or transition structure across admissible histories	Which future pathways should become more or less reachable without fixing one outcome?	Weight semantics can be overinterpreted or confused with probability

regimes; a changed classification can transform subject standing; a capacity intervention can generate new actions; a rule-level intervention can reshape entire history families. Target selection should therefore specify both the *focal target* and the sur-

rounding targets that are expected to move as consequences or enabling conditions.

Definition 11.269 (Focal and consequential targets). A *focal target* is the practical object toward which an intervention is primarily directed. A *consequential target* is another object expected to change materially because of the intervention even though it is not the principal object of purposive transformation.

This distinction prevents target descriptions from becoming artificially isolated. If a classification reform is the focal target and institutional standing changes as a consequence, both belong in the intervention record. If a capability program is the focal target but it predictably alters dependency relations, the relational consequence should be represented before implementation where possible. Target selection is therefore a mapping problem across a layered generative field rather than the identification of one independent variable.

11.15.1 State Variables

State-variable targets concern observable or modeled conditions that can be represented at a particular stage of the practical system. They are often the most operationally accessible intervention objects because they can be measured, monitored, and connected to explicit criteria. Examples in a domain-general vocabulary include resource levels, waiting times, participation rates, exposure measures, temperatures, inventories, response latency, observed prevalence, or another locally defined state descriptor. Their methodological usefulness lies in making a desired change sufficiently specific to organize action and evaluation.

A state variable should nevertheless be treated as a representation of a practical condition rather than the condition in its entirety. Section 11.12 established that state construction depends on a model boundary, measurement mapping, temporal resolution, and interpretive scope. Targeting a measured state can therefore improve the indicator while leaving the relations or mechanisms that generate the state unchanged. An intervention that reduces a backlog by temporarily adding extraordinary personnel, for example, changes the state while potentially leaving institutional capacity, workflow relations, or generative bottlenecks intact. The state can later return toward its earlier configuration once the temporary input disappears.

Definition 11.270 (State-target profile). A *state-target profile* records the state variable or state representation selected for intervention, its measurement and boundary assumptions, the desired direction or admissible region of change, its relation to underlying generative mechanisms, and the conditions under which improvement in the represented state would be insufficient evidence of practical improvement.

State targeting can be appropriate when the practical objective is genuinely state-like. Emergency stabilization, restoration of a minimum stock, reduction of acute exposure, or maintenance of a bounded operating condition can require direct state intervention even when deeper mechanisms remain only partly understood. The important methodological discipline is to specify whether the state change is intended as stabilization, symptom relief, protective buffering, diagnostic probe, or durable transformation. These purposes imply different expectations about persistence and different requirements for complementary targets.

State targets can also possess threshold structure without reducing the entire intervention architecture to threshold logic. A safety variable may need to remain within an admissible interval. A service-level variable can trigger escalation when it crosses a locally justified boundary. Such thresholds are legitimate when their provenance and semantics are explicit. They do not establish that every practical target can be represented through one scalar state or that crossing the threshold identifies the complete intervention response.

State targeting should therefore be accompanied by a *state-generation question*: which relations, capacities, institutions, fields, or rules produce and reproduce the targeted state? The answer can remain provisional, but asking the question prevents operational convenience from being mistaken for generative explanation.

11.15.2 Relations

Relational targets concern the connections through which practical configurations are constituted and transformed. Relevant relations can include dependency, authority, trust, communication, care, exchange, exposure, coordination, recognition, representation, obligation, maintenance, or access. An intervention can seek to establish a missing relation, weaken an exploitative dependency, strengthen a fragile coordination link, redirect a flow, protect a care relation, rebalance authority, or create a new interface among previously disconnected positions.

Definition 11.271 (Relational intervention target). A *relational intervention target* is a specified relation or relational configuration whose existence, direction, intensity, quality, accessibility, composition, or governance is selected for purposive practical change.

Relation targeting differs from changing attributes of the positions connected by the relation. Two positions can retain similar individual capabilities while their dependency changes substantially. Conversely, training both positions can leave a dysfunctional authority relation untouched. This is why actor-level or state-variable interventions do not automatically produce relational transformation.

Relational targets should also preserve multiplicity. The same pair of positions can be connected simultaneously through trust, authority, information, resource dependence, contractual obligation, friendship, or exposure. Strengthening one relation can weaken or distort another. A centralized information interface can improve coordination while increasing surveillance dependence. A new contractual relation can improve formal accountability while weakening informal cooperation. A *relational target profile* should therefore record the type of relation being targeted and the adjacent relations likely to change.

Higher-order relations require particular care. Some practical configurations cannot be decomposed adequately into pairwise ties. A committee rule, shared infrastructure, multi-party coordination protocol, or collective norm can depend on interactions among several positions simultaneously. Section 11.12 introduced higher-order representations for such cases. Target selection should use them where pairwise simplification would erase the mechanism through which the intervention is expected to work.

A relation can itself have history. Trust generated through repeated interaction differs from a formally imposed coordination relation even when a present network diagram represents both as edges. Relational intervention should therefore ask how the relation was produced, what maintains it, what expectations it carries, and what would be lost if it were replaced. This historical dimension becomes especially important when the target relation contributes to the continuity of the subjects connected through it.

Proposition 11.272 (Relational target adequacy). *Relational targeting is practically stronger when the selected relation is typed, historically situated, connected to adjacent and higher-order relations, and linked to a plausible account of how its transformation changes later practical possibilities.*

11.15.3 Historical-Relational Subjects and Entities

Some interventions are directed toward subjects or entities whose practical identity cannot be reduced to a point state. Earlier sections established that a subject can be modeled as a historical-relational object: a configuration whose continuity depends on events, internal relations, external relations, capacities, classifications, institutional positions, memories, and commitments accumulated through time. Target selection should preserve this structure when intervention is expected to change the subject itself rather than merely one measured attribute.

A historical-relational subject target can concern capability formation, legal or institutional standing, internal coordination, memory, recognized identity, relation to other actors, or the conditions through which the subject maintains continuity. Examples include strengthening a collective's capacity for self-governance, restoring an organization's institutional memory, changing the standing of an affected group, supporting recovery of a damaged relational identity, or reorganizing an entity whose internal structure generates repeated failure. These are not well represented by treating the subject as one scalar variable.

Where a formal representation is useful, a subject can be represented schematically by a finite labeled historical-relational structure. Equation 11.34 gives one optional representation.

$$\mathcal{C}_s = (V_s, E_s, F_s, \preceq_s, \lambda_s). \quad (11.34)$$

In Equation 11.34, vertices can represent events or states, edges can represent typed relations or transitions, faces can represent higher-order composition, $\preceq_s$ can encode partial historical precedence, and λ_s can provide model-specific labels. A labeled 2-complex is one possible realization of this structure. Narrative, institutional, network, dynamical, or agent-based representations remain equally admissible when they better fit the practical object.

Definition 11.273 (Subject-target boundary). A *subject-target boundary* specifies which internal events, relations, capacities, institutional positions, external interfaces, and historical conditions are included in the intervention representation of a subject or entity and which remain outside the current target model.

This boundary matters normatively and practically. Intervention directed at a per-

son, community, organization, or collective can become overly individualizing if it locates a practical problem inside the subject while omitting the relations and institutions that generate the condition. The opposite error is also possible: an intervention can treat subjects only as positions in a structure and neglect internal capability, memory, meaning, or agency. Historical-relational targeting seeks to retain both the subject's internal organization and the external relations through which that organization is constituted.

Subject targeting should also distinguish transformation from replacement. If an intervention reorganizes internal relations so extensively that the later entity has different continuity conditions, governance, membership, or identity, the practical question can exceed ordinary capability enhancement. Target selection should record this possibility before later sections determine intervention depth and legitimacy.

11.15.4 Structures

Structural targets concern recurrent configurations that organize many local relations or trajectories. A structure can be represented through hierarchy, topology, role distribution, repeated dependency, segmentation, institutional layering, resource concentration, network architecture, categorical ordering, or another durable pattern whose effects cannot be attributed adequately to one local relation. Structural targeting therefore asks which configuration repeatedly reproduces the practical condition across cases, positions, or time.

Definition 11.274 (Structural intervention target). A *structural intervention target* is a recurrent relational or organizational configuration whose topology, ordering, distribution, interface pattern, or reproduction mechanism is selected for purposive transformation.

The term *structure* should not function as a substitute for mechanism. A diagnosis that identifies a problem as “structural” remains methodologically incomplete until it specifies what pattern is being referred to and how that pattern constrains or generates later possibilities. A hierarchy can reproduce unequal authority through role rules. A network can concentrate dependency around a central node. A classification architecture can repeatedly exclude positions whose attributes do not fit its categories. These are different structures and require different interventions.

Structural targets often interact with local adaptation. Actors can compensate for a problematic structure through workarounds, informal relations, or exceptional effort. Directly removing those compensations without altering the structure can worsen outcomes. Conversely, local adaptation can conceal structural failure and make the structure appear more functional than it is. Target selection should therefore distinguish *structure-maintaining adaptation* from *structure-transforming adaptation*.

A structural intervention can also redistribute fragility. Decentralizing one coordination structure can reduce concentration risk while increasing interface complexity. Centralizing a fragmented process can improve consistency while creating a single point of failure. Structural evaluation should therefore connect to the robustness, scale, and institutional analyses developed elsewhere in the chapter.

Definition 11.275 (Structural reproduction profile). A *structural reproduction profile* records the relations, rules, resources, routines, expectations, and feedback processes through which a targeted structure is maintained or regenerated across relevant positions and time horizons.

This profile helps determine whether a proposed intervention actually reaches the structure or merely alters one manifestation of it. It also prepares the later distinction between structural intervention and rule-level intervention: some structures can change while formal rules remain constant, while others are reproduced precisely through the rules that define admissible transformations.

11.15.5 Constraints

Constraint targets concern conditions that limit reachable actions, transitions, participation, or outcomes. Section 11.2 distinguished hard, soft, and contingent constraints during diagnosis, while Section 11.12 treats technical, institutional, protective, and constitutive constraints as possible inputs to formal optimization and search. Intervention target selection now asks which constraint should be relaxed, transformed, preserved, redistributed, or made explicit in order to change the practical trajectory.

Definition 11.276 (Constraint target profile). A *constraint target profile* records the selected constraint, the positions and actions it restricts, its practical function, modifiability, dependencies, protective or constitutive role where relevant, and the expected consequences of weakening, strengthening, relocating, or redesigning it.

A constraint should not be presumed undesirable merely because it limits action. Safety requirements, rights, ecological boundaries, separation of powers, review procedures, and professional standards can restrict immediate flexibility while preserving other values or long-horizon capacities. The intervention question can therefore be whether the constraint is mislocated, excessively rigid, poorly calibrated, asymmetrically imposed, or disconnected from the practical object it is intended to protect.

Constraints can also be relationally distributed. The same formal requirement can impose very different practical restrictions on actors with different resources, language access, institutional familiarity, mobility, or technological capability. Removing the formal constraint can improve reachability for one position while exposing another to greater risk. Constraint targeting should therefore include a *constraint incidence profile* showing who bears the restriction, who benefits from it, and who possesses capacity to navigate or modify it.

Some constraints interact multiplicatively. A small language barrier, scheduling difficulty, procedural requirement, and mobility limitation can jointly foreclose participation even when no single factor appears decisive. Intervention can therefore target a *constraint configuration* rather than one isolated restriction. This relational treatment is especially important when practical exclusion emerges from several weak constraints whose combination closes an action pathway.

Constraint transformation can generate new possibilities and new risks simultaneously. Relaxing an institutional permission rule can enlarge the action space while weakening accountability. Removing a technical bottleneck can increase throughput while overloading maintenance capacity. The constraint target should therefore re-

main connected to the later action-space and history-space consequences of its modification.

11.15.6 Capacities

Capacity targets concern effective abilities to sense, interpret, decide, coordinate, act, maintain, learn, repair, adapt, contest, or revise. A capacity is not identical to possession of resources. Resources become capacity only through activation pathways involving knowledge, authority, organization, access, time, relations, infrastructure, and institutional support. Target selection should therefore identify which capability is practically absent or fragile and which conditions allow it to become usable and durable.

Definition 11.277 (Capacity intervention target). A *capacity intervention target* is an effective practical ability, or a configuration of complementary abilities, selected for generation, strengthening, distribution, preservation, regeneration, or recovery.

Capacity interventions can operate at several levels. An individual can acquire skill. A team can develop coordination routines. An institution can develop monitoring or repair capability. A community can develop collective organization. A system can acquire redundancy, memory, or capacity to generate new options. These targets are related but not interchangeable. Training individuals does not automatically produce institutional capacity; acquiring infrastructure does not automatically produce maintenance capability; formal authority does not automatically generate implementation capacity.

Target selection should therefore distinguish *capacity stock*, *capacity activation*, and *capacity regeneration*. A stock is an available resource or competence. Activation concerns whether it can be mobilized in the practical situation. Regeneration concerns whether the capacity can be maintained, reproduced, transferred, or rebuilt after use or disruption. An intervention can create strong short-term activation while weakening regeneration through burnout, dependency on exceptional actors, or depletion of reserves.

Definition 11.278 (Capacity-generativity profile). A *capacity-generativity profile* records how a targeted capacity is produced, activated, maintained, transmitted, regenerated, and connected to the generation of later practical possibilities.

Capacity targeting is especially important when the present action space is inadequate. Section 11.10 established action-space regeneration as a core adaptive method. Generating a new action often requires generating the capacity to perform it. In such cases, capacity is not merely an enabling condition attached to an intervention; it is the focal intervention target through which a new practical branch becomes reachable.

Capacity distribution also matters. Concentrating technical capability in one institution can improve immediate performance while increasing dependency and weakening distributed resilience. Distributing capability can increase redundancy and local agency while generating coordination costs. Target selection should therefore record whose capacity is being strengthened and how that change modifies relations of dependence, authority, and future option generation.

11.15.7 Institutions

Institutional targets concern the durable arrangements through which mandates, authority, roles, routines, records, resources, expectations, accountability, and interfaces organize collective praxis. Chapter 10 developed institutions as generative media rather than passive containers. Intervention target selection therefore asks which institutional function, relation, memory system, coordination interface, mandate, accountability pathway, or revision mechanism should be transformed.

Definition 11.279 (Institutional intervention target). An *institutional intervention target* is a specified element or configuration of institutional mandate, authority, role, routine, memory, resource arrangement, interface, accountability relation, or self-revision capacity selected for purposive practical change.

Institutional targeting should distinguish formal design from enacted configuration. A written rule can remain unchanged while front-line routines, informal coordination, interpretation, or practical authority shift substantially. Conversely, a formal reform can produce little practical change when the organization lacks capability, memory, trust, or implementation pathways. An institutional target profile should therefore contain both the formal object and the enacted mechanism through which the institution currently operates.

Institutional memory can itself be the target. A recurring failure can persist because reasons, warnings, or prior experiments disappear across personnel transitions. A handoff protocol, provenance system, durable review role, or archival interface can therefore be an intervention directed at memory rather than at the substantive decision itself. Likewise, self-revision capacity can be targeted when an institution repeatedly encounters new conditions but lacks authority or procedure to alter its own rules.

Institutional interventions often redistribute power. Changing who can authorize action, who can access records, who can initiate review, or who can define categories modifies practical power even when the intervention is described procedurally. Target selection should therefore connect institutional targets to the power, participation, responsibility, and justice architectures developed in Chapter 10.

A practical institution also operates through interfaces with other institutions. Many failures occur between organizations whose internal procedures are individually competent. Target selection can therefore focus on an *institutional interface*: the protocol, data relation, responsibility boundary, escalation route, or coordination mechanism through which two institutional configurations interact. Interface targeting is often more precise than treating either organization as a unitary target.

11.15.8 Observation and Representation Regimes

Observation and representation regimes become intervention targets when practical trajectories are materially shaped by what can be seen, recorded, classified, measured, modeled, or institutionally recognized. The revised epistemic architecture of Section 11.4 distinguishes observation as readout from transformation while allowing epistemic events to become performatively coupled to changes in the field. Intervention can therefore be directed toward the epistemic interface itself.

Definition 11.280 (Observation-regime target). An *observation-regime target* is a specified element of the categories, indicators, measurement procedures, records, classification systems, models, reporting channels, visibility rules, or interpretive conventions through which a practical field becomes observable and actionable.

Changing an observation regime can alter what becomes legible. A new category can reveal a previously aggregated burden. A different temporal resolution can expose cyclical failure hidden by annual averages. Participatory monitoring can reveal local variation. A new reporting channel can make weak signals visible before they become system-level failures. These interventions change epistemic access even before any downstream decision changes.

Observation-regime intervention can also be performative. Once a category determines eligibility, a metric becomes a target, a rating affects resource allocation, or a classification changes legal standing, the representation participates in the practical field it describes. The intervention therefore needs both an epistemic and a relational consequence profile. Improving measurement precision can still produce harmful effects if the measure concentrates surveillance, creates strategic gaming, excludes unclassifiable positions, or transfers interpretive authority away from affected subjects.

Definition 11.281 (Representational intervention profile). A *representational intervention profile* records the representation being changed, the practical objects newly included or excluded, the epistemic gain sought, the positions controlling the representation, expected performative effects, strategic response risks, and conditions for revision or retirement of the representation.

Observation and representation targets can also include the model family itself. A practical system repeatedly analyzed through one model can develop blind spots that are not solved by adding more data to the same representation. Introducing an alternative model, preserving incompatible representations in parallel, or changing the mapping between observations and models can therefore be a legitimate intervention. This is especially relevant when model disagreement reveals omitted actors, scales, mechanisms, or histories.

Because observation can change behavior, intervention design should avoid the fiction that monitoring is always external to the system. Section 303 later develops monitoring methodology in detail. The present section establishes the prior target-selection question: whether the observation regime itself is one of the objects that needs purposive change.

11.15.9 Fields

Field targets concern distributed conditions that influence local possibilities, interactions, or transformations across a practical domain. A field representation can capture variation in opportunity, constraint, information, trust, exposure, institutional influence, accessibility, or another quantity whose local value depends on a broader relational configuration. Field targeting is useful when no single actor or relation adequately represents the distributed condition the intervention seeks to alter.

Definition 11.282 (Field intervention target). A *field intervention target* is a dis-

tributed practical condition, represented over a specified relational, spatial, institutional, or historical carrier domain, whose local values, gradients, couplings, boundary conditions, or evolution are selected for purposive change.

A field target requires explicit semantics. The carrier domain, units or categories, locality relation, boundary conditions, coupling assumptions, and observation mapping should be stated. Otherwise field language can become a metaphor that names widespread influence without specifying what is distributed or how local change is connected to the broader configuration.

Where a formal field representation is useful, a field φ_t can parameterize local transformation conditions. Equation 11.35 provides a schematic intervention representation.

$$\varphi_{t+1} = \Psi_t(\varphi_t; au_t, e_t, \omega_t), \quad (11.35)$$

In Equation 11.35, τ_t denotes a model-specific intervention directed toward the field, while e_t permits epistemic events to affect the update where the model represents such coupling. The equation does not prescribe one physical interpretation of φ_t ; the field semantics remain specific to the practical model.

Field intervention can operate through local actions whose effects propagate, through changes to boundary conditions, through distributed infrastructure, or through modification of coupling among local positions. The same field can also respond unevenly because local capacities, institutions, or histories differ. Target selection should therefore avoid assuming spatial or relational homogeneity merely because the representation uses one field variable.

Field targeting also creates a scale question that Section 299 will address directly. A field can be represented at several resolutions, and a local intervention may appear negligible at one scale while substantially changing a critical interface at another. The target architecture should preserve enough resolution to identify where field transformation becomes practically consequential.

11.15.10 Generative Conditions

Generative-condition targets concern the conditions under which later capacities, relations, institutions, values, knowledge, actions, or other practically relevant possibilities can emerge and persist. Their importance follows directly from the generative orientation of GR. An intervention can be valuable because it creates a desired immediate state, but it can also be valuable because it changes the conditions under which future actors can generate, revise, or sustain valued possibilities themselves.

Definition 11.283 (Generative-condition target). A *generative-condition target* is a condition, relation, resource configuration, institutional arrangement, epistemic interface, or capability whose practical significance lies materially in how it enables, suppresses, redirects, sustains, or regenerates later processes of generation.

Generative conditions differ from ordinary intermediate variables because their analytical role is explicitly future-producing. Trust can enable later coordination. Educational or technical capability can generate later action alternatives. Institutional memory can enable later error correction. Open standards can enable recombina-

tion. Safe participation channels can generate future knowledge. Repair capacity can preserve future reversibility. These conditions can be targeted even when their immediate output contribution is difficult to summarize in one metric.

A generative-condition intervention should distinguish *generation for whom* and *generation of what*. A system can become more generative for a central institution while reducing the ability of peripheral actors to initiate action. A platform can increase total innovation while concentrating control over access. An institution can generate more information while decreasing interpretive autonomy. Generativity is therefore not automatically normatively positive; its distribution and governance remain part of the target architecture.

Definition 11.284 (Generative-target incidence profile). A *generative-target incidence profile* records which positions gain or lose capacities for later generation, which objects or processes become easier or harder to generate, which dependencies mediate that change, and which future options are created, preserved, transformed, or foreclosed.

Generative-condition targeting can also be indirect. An intervention can protect a condition rather than maximize it. Maintaining diversity, preserving institutional slack, sustaining multiple knowledge traditions, or retaining repair capacity can protect the field's ability to respond to futures that cannot yet be specified. Such interventions connect directly to generative robustness from Section 11.9.

This target layer will become especially important when the book later returns to substantive GRE. Economic allocation, value transmission, institutional design, and productive capability can all be analyzed partly through the generative conditions they create or destroy. The present section keeps the concept domain-general so that later economic chapters can specialize it without altering its general praxis architecture.

11.15.11 Rule-Level Targets

Rule-level targets concern the transformation rules, permissions, update procedures, composition structures, or admissibility conditions through which the practical configuration evolves. They are deeper than changing one present state because they alter how future states or histories are generated from current conditions. A rule-level intervention can modify who is permitted to act, how decisions are composed, how resources are assigned, how categories update, how institutional responsibilities transfer, or how local transformations interact.

Definition 11.285 (Rule-level intervention target). A *rule-level intervention target* is a specified transformation rule, permission structure, composition law, update regime, or admissibility condition whose revision changes how subsequent practical configurations or histories can be generated.

A simple schematic distinction can be made between intervention within a rule and intervention on the rule. Equation 11.36 represents the latter.

$$F_{t+1} = \mathcal{T}_t(F_t; \tau_t, e_t, \omega_t). \quad (11.36)$$

In Equation 11.36, F_t denotes a model-specific rule or family of transformations

governing evolution, and $\mathcal{T}_t$ denotes a higher-level transformation that changes that rule. The expression is intentionally general. In one model F_t can be a transition law; in another it can be an institutional update procedure, operator family, governance rule, or algorithmic policy.

Rule-level interventions can have broad consequences because they alter many later transitions rather than one local outcome. They can also create path dependence: once actors, institutions, or infrastructures adapt to a new rule, restoring the old rule may not restore the earlier field. Rule targeting therefore requires especially careful treatment of reversibility, transition management, monitoring, and responsibility.

Rule-level intervention also interacts with power. The capacity to define the rule governing others' actions can be more consequential than the capacity to choose within that rule. An institution that sets eligibility, classification, authorization, or update procedures can shape action spaces for positions that never participate directly in the rule-making process. Target selection should therefore identify who controls rule revision and who bears its downstream consequences.

Some apparent rule failures are actually implementation or capacity failures. Rewriting a rule when the problem is lack of coordination, maintenance, information, or enforcement can increase complexity without changing practical behavior. Conversely, repeated local exceptions can indicate that the rule itself no longer fits the field. Rule-level targeting should therefore be supported by diagnostic evidence that distinguishes the rule from the capacities and relations through which it is enacted.

11.15.12 History and Transition Potentials

The final target layer concerns the relative accessibility, plausibility, propensity, or other model-specific weighting of future histories. The revised GR architecture developed in Sections 11.4–11.10 allows practical evolution to be represented through families of admissible histories whose weights or transition potentials can change after epistemic events, interventions, subject transformations, or institutional change. Intervention need not therefore be represented only as movement toward one target state. It can be directed toward changing which future histories become easier, harder, newly admissible, or effectively foreclosed.

Definition 11.286 (History-potential target). A *history-potential target* is a model-specific feature of the admissible-history or transition architecture selected for change because it affects the relative accessibility, support, propensity, plausibility, or reachability of subsequent histories.

For a nonnegative history-weight representation, an intervention can be modeled schematically as a transformation of a weight functional. Equation 11.37 gives one general form.

$$W_{t+1} = \mathcal{Q}_t [W_t; \tau_t, e_t, \omega_t]. \quad (11.37)$$

In Equation 11.37, the semantics of W_t must be stated by the model. It can represent probability where normalized stochastic semantics are justified, or another non-

negative quantity such as accessibility, plausibility, transition propensity, empirical frequency, or simulation mass. The target is the represented distribution or ordering of future pathways, not a metaphysical potential assumed to exist independently of the model.

History-potential targeting can occur through many practical means. An early warning system can increase the accessibility of protective histories by enabling faster response. Capability building can make previously latent intervention branches reachable. Legal reform can open institutional pathways. A credible sanction can make some harmful trajectories less attractive to strategic actors. Investment in repair capacity can increase the accessibility of recovery histories after disruption. Participatory recognition can generate new collective pathways that did not previously belong to the effective action space.

The intervention can also change the history space itself. Equation 11.37 represents reweighting only where the relevant histories remain represented. A stronger transformation can create new branches, remove branches, alter event order, change composition rules, or transform the subject whose future is being represented. Target selection should therefore distinguish *history reweighting* from *history-space transformation*.

Definition 11.287 (History-space transformation target). A *history-space transformation target* is a practical object whose transformation is intended to create, remove, merge, separate, reorder, or otherwise change the admissible family of represented future histories rather than merely change weights over a fixed family.

A 2-complex or partial-order model can represent such intervention by changing admissible extensions, incidence relations, labels, or precedence constraints. An operator model can change the transformation family available at a stage. An agent-based model can generate new rules or capabilities. A narrative or institutional model can represent the same practical transformation without numerical weights. No single computational language is privileged.

Amplitude-like models remain an optional stronger specialization. If a model assigns complex amplitudes to histories, the intervention target can concern amplitude structure only after the model supplies explicit semantics for composition, phase, observation, and empirical interpretation. The presence of a 2-complex or ordered event structure is not sufficient to justify amplitude semantics. The general target architecture therefore remains expressed through admissible histories, transition structure, and explicitly interpreted weights or potentials.

History-potential targeting also raises a justice question. Making one future more accessible can make another less accessible, and the relevant histories can differ across affected positions. An intervention that increases aggregate probability of system stability can simultaneously narrow exit, autonomy, or future option space for a particular group. Target selection should therefore record whose future pathways are being widened, narrowed, protected, or foreclosed.

Definition 11.288 (Target-coupling record). A *target-coupling record* documents the focal intervention target, consequential targets, expected direction of change, represented mechanism of coupling among target layers, affected positions, uncertainty, possible history-space effects, and the observations that would trigger revision of the

target architecture.

The target-coupling record provides the integrative output of this section. A practical intervention rarely changes only one layer. State, relation, subject, structure, constraint, capacity, institution, observation regime, field, generative condition, rule, and history architecture can interact. The methodological task is therefore to select a focal target while preserving a sufficiently explicit representation of the coupled objects through which intervention can propagate.

Proposition 11.289 (Layered target-selection principle). *Intervention target selection is practically stronger when the focal target is distinguished from consequential targets, located within a layered historical-relational architecture, connected to a plausible generative pathway, assessed for distributional and epistemic effects, and revised when observation or implementation shows that the intervention is acting on a different practical object from the one originally specified.*

Proposition 11.289 completes the target-selection stage without yet determining when, where, or how deeply intervention should occur. The same target can be appropriate at one temporal window and inaccessible at another; two valid targets can require a particular order; and intervention can change the field so that a later target becomes reachable only after an earlier one has been transformed. The next section therefore turns from target architecture to the temporal architecture of intervention through timing, windows of possibility, critical junctures, event order, generative precedence, and adaptive sequencing.

11.16 Timing and Sequencing

Intervention target selection specifies what part of a practical configuration is intended to change. Timing and sequencing specify how intervention events are situated within an ordered practical history, which events or conditions precede others, which events remain unordered, and how later transformations become reachable through earlier ones. The role of this section is to develop the temporal architecture of intervention design before scale and depth are selected in Sections 299 and 298. The discussion proceeds from intervention timing and windows of possibility to critical junctures, generative precedence, order-sensitive operator composition, temporal coordination, delayed effects, staged intervention, and adaptive sequencing. The method is relational and dynamical. Within the present GR framework, historical time is represented primarily through order relations among events rather than by presuming a universal external clock. Calendar dates, durations, and continuous-time parameters remain available as model-specific labels or embeddings when they are useful.

Definition 11.290 (Event-ordered practical time). *An event-ordered practical time is a model-specific temporal structure*

$$\mathcal{T}^{(m)} = \left(\mathcal{E}^{(m)}, \preceq^{(m)}, \lambda^{(m)} \right), \quad (11.38)$$

in which $\mathcal{E}^{(m)}$ is a set of practical, epistemic, institutional, or other modeled events, $\preceq^{(m)}$ is a partial order encoding the precedence relations represented as temporally or

generatively relevant, and $\lambda^{(m)}$ contains optional event labels such as actor, location, institutional role, clock date, duration, or other model-specific information. Events that are incomparable under $\preceq^{(m)}$ are left unordered by the model rather than being forced into a total temporal sequence.

Equation 11.38 provides the primary temporal representation used in this section. The partial order can represent causal, generative, institutional, or procedural precedence according to the model. An order-compatible clock-time map $\tau : \mathcal{E}^{(m)} \rightarrow \mathbb{R}$ can be added when useful, but τ functions as a coordinate or label rather than as the definition of historical time itself. Where such an embedding is used, $e_i \prec e_j$ normally constrains the admissible clock ordering, while incomparable events need not be interpreted as simultaneous. A labeled 2-complex can provide a richer representation when events, relations, and higher-order composition need to be preserved together.

For an event $e \in \mathcal{E}^{(m)}$, its represented historical past and future can be written as Equation 11.39.

$$\downarrow e = \{e' \in \mathcal{E}^{(m)} : e' \preceq e\}, \quad \uparrow e = \{e' \in \mathcal{E}^{(m)} : e \preceq e'\}. \quad (11.39)$$

Equation 11.39 makes explicit that practical history can be reconstructed through event ancestry and admissible continuation rather than only through scalar time differences.

Definition 11.291 (Temporal intervention architecture). A *temporal intervention architecture* records the event-order structure, timing labels where relevant, precedence and concurrency relations, coordination requirements, expected delays, stage boundaries, review conditions, and adaptive resequencing rules through which one or more interventions are organized across a practical history.

Timing matters because the same intervention target can have different consequences under different relational conditions. A capacity-building programme introduced before responsibility is delegated can support later autonomy; the same programme introduced after dependency has become entrenched may operate as repair. A new observation regime introduced before authorization can inform design; introduced after implementation, it may mainly document consequences. An intervention can therefore be well targeted and still perform poorly because its temporal relation to enabling conditions, epistemic events, institutional readiness, or irreversible processes is mis-specified.

Table 11.16 summarizes the temporal dimensions developed in this section. The dimensions are analytically distinct but practically coupled. A critical juncture can create a window of possibility; a staged intervention can preserve a window while generating evidence; delayed effects can alter the appropriate sequence; adaptive sequencing can reorder later stages after a performative epistemic event changes the field.

11.16.1 Intervention Timing

Intervention timing concerns the placement of a contemplated intervention event within the ordered practical history in which it will operate. A timing decision should therefore identify the event-order conditions that make the intervention reachable,

Table 11.16: Temporal architecture of intervention timing and sequencing.

Temporal dimension	Practical object	Characteristic design question	Characteristic concern
Intervention timing	Placement of an intervention event within an ordered practical history	Under which predecessor conditions does the intervention become reachable and consequential?	Clock-time labels can obscure event-order dependence and generative readiness
Possibility windows	Bounded regions of event-order reachability or leverage	Under which temporary relational conditions are actions reachable or especially consequential?	Clock intervals can misrepresent windows generated by event dependencies
Critical junctures	Periods of amplified path formation	When can comparatively small changes alter later institutional or relational trajectories?	Salience can be mistaken for structural leverage
Generative precedence	Dependency relations among events and capacities	Which event or condition must be generated before another can function as intended?	Calendar order can conceal deeper logical or relational precedence
Operator sequencing	Order-sensitive composition of transformations	Does changing intervention order alter the resulting practical configuration?	Sequence effects can be lost when interventions are treated as additive
Temporal coordination	Alignment across actors, institutions, and timescales	Which activities must occur together, overlap, or remain separated?	Local synchronization can create fragility at another timescale
Delayed effects	Consequences emerging after implementation	Which effects, feedbacks, and burdens appear only after a lag?	Early evaluation can misclassify a trajectory before delayed effects mature
Staged intervention	Bounded sequence of commitments and review gates	Which commitments should be divided into stages with explicit continuation conditions?	Staging can become symbolic if later stages are effectively predetermined
Adaptive sequencing	Revision of order as the field evolves	How should the remaining sequence change after new evidence, events, or capacities emerge?	Undocumented resequencing can become methodological drift

supportable, or especially consequential, while adding clock or calendar information only where that information performs a genuine analytical or operational role. Relevant predecessor conditions can include institutional readiness, available capacity, accumulated knowledge, affected-subject participation, legal authorization, resource availability, seasonal or ecological conditions, political attention, technological maturity, or the approach of an irreversible transformation.

Definition 11.292 (Intervention timing profile). An *intervention timing profile* records the contemplated intervention, the relevant temporal horizon, enabling and constraining conditions, urgency, readiness, expected consequences of earlier or later action, reversibility, monitoring capacity, and the conditions under which the timing judgment should be revised.

A useful timing judgment separates at least three temporal questions. *Urgency* concerns how delay changes consequences. *Readiness* concerns whether the practical capacities, authority, knowledge, and safeguards required for action are presently

available. *Opportunity* concerns whether the current configuration offers leverage that may later weaken or disappear. These dimensions can diverge. A situation can be urgent while institutional readiness remains weak; a system can be highly ready while the practical benefit of immediate action is small; an opportunity can be unusually favorable even when the underlying problem is not newly urgent.

Timing also changes the meaning of evidence. An observation can be decisive before an irreversible commitment and merely explanatory afterward. A warning signal can have high practical value while options remain open and much lower value after a cascade has passed a containment point. Section 11.4 therefore matters directly for timing: an epistemic event can modify the field, the action space, or the relative support of later histories. The decision about when to act should consequently include the expected value and performative effects of waiting for additional observation.

A model-specific intervention can be attached to an event e_a whose admissible predecessors are represented by a set $P(e_a)$. One simple event-structure update is given in Equation 11.40.

$$\mathcal{E}' = \mathcal{E} \cup \{e_a\}, \quad \preceq' = \text{tc}(\preceq \cup \{(p, e_a) : p \in P(e_a)\}), \quad (11.40)$$

where tc denotes transitive closure. Equation 11.40 is schematic: it represents intervention timing as insertion or activation within an event-order structure rather than as movement from t to $t + 1$. If a particular model admits an order-compatible scalar clock τ , the intervention event can additionally carry a timestamp $\tau(e_a)$, but that timestamp does not exhaust the temporal relation that gives the intervention its practical meaning. Two interventions with similar clock dates can occupy different positions in the partial order because different epistemic, institutional, or relational predecessors have been generated.

Timing decisions should also preserve the cost of temporal commitment. An intervention that begins now can occupy staff, political attention, infrastructure, legal authority, or financial resources that would otherwise remain available later. Conversely, postponement can preserve flexibility while allowing deterioration or lock-in. A *temporal opportunity-cost record* can therefore document which future capacities or possibilities are consumed, preserved, or generated by acting at the selected time.

11.16.2 Windows of Possibility

A window of possibility is a temporally bounded interval in which a practical action is reachable, legitimate, sufficiently supported, or unusually capable of changing a trajectory. Windows can arise from temporary institutional alignment, resource availability, seasonal conditions, public attention, technological capability, legal authorization, relational trust, or the temporary reversibility of a process. Their methodological importance lies in connecting time to action-space reachability.

Definition 11.293 (Possibility window). A *possibility window* is a bounded region of an event-ordered practical history in which one or more actions possess materially different reachability, expected leverage, legitimacy, reversibility, or implementation conditions than they possess outside that region. Where an order-compatible clock

embedding is useful, such a region may also be represented by one or more clock intervals.

A possibility window should be reconstructed through the conditions that open, sustain, and close it. This helps distinguish a genuine temporal opportunity from an arbitrary deadline. A window can open because a coalition forms, a capacity becomes available, a risk becomes visible, or a technical threshold is reached. It can close because attention dissipates, authority changes, a resource is depleted, an institution locks in another trajectory, or an ecological or technical process crosses an irreversible boundary.

Windows can also be generated deliberately. A temporary authorization, pilot infrastructure, bridge financing, protected deliberative period, moratorium, reserve capacity, or reversible sandbox can create an interval within which learning and coordinated action become possible. In this sense, timing methodology can itself be generative: praxis can produce the temporal conditions required for a later action rather than merely wait for an exogenous opportunity.

Definition 11.294 (Window-generation intervention). A *window-generation intervention* is an action whose principal temporal function is to create, extend, reopen, or protect an interval in which another practically relevant action becomes reachable, safer, more legitimate, or more revisable.

This concept is useful where immediate substantive intervention remains premature but delay would close the action space. A temporary stabilization measure can preserve a future choice; a short-term legal arrangement can create time for participatory design; reserve capacity can keep rollback possible while evidence accumulates. The resulting intervention should be evaluated partly through the quality of the later action space it preserves or generates.

Possibility windows can differ across subjects. A decision-maker can perceive a wide window because institutional resources allow waiting, while affected subjects experience a narrowing window because harm accumulates daily. Timing analysis should therefore include a *positional window profile* that records whose options expand or contract across the relevant interval. This prevents an institution's capacity to wait from being mistaken for a universally shared temporal condition.

11.16.3 Critical Junctures

A critical juncture is a period in which the practical field exhibits unusually high sensitivity to decisions, events, or institutional commitments relative to surrounding periods. The concept is useful when early changes can redirect later relations, norms, infrastructures, expectations, or action spaces and thereby create persistent path dependence. Within the present framework, a critical juncture is defined through practical sensitivity and path formation rather than through rhetorical importance alone.

Definition 11.295 (Practical critical juncture). A *practical critical juncture* is a temporally localized configuration in which a bounded set of actions or events can materially alter the later generative structure, institutional path, relational organization, or reachable history space of the practical field.

Critical-juncture identification should specify the mechanism of amplified conse-

quence. A new institution may be forming before routines harden. A technical standard may be selected before compatibility networks accumulate. A collective subject may be negotiating internal rules before authority stabilizes. A crisis may temporarily loosen an earlier constraint. These mechanisms differ, and their intervention implications should be modeled separately.

The concept also requires restraint. Visibility, urgency, and political salience can coincide with a critical juncture, yet none of them establishes one by itself. A highly visible event can leave the deeper generative architecture unchanged, while a low-visibility procedural change can strongly shape later possibilities. A *juncture sensitivity profile* should therefore record the target layer, candidate pathways, expected persistence, reversibility, affected positions, and uncertainty concerning the alleged amplification mechanism.

Critical junctures can be epistemically difficult because evidence is often weakest precisely when the field is changing most rapidly. Historical analogies can fail, model parameters can drift, and institutions can improvise. This makes reversibility, staging, plural models, and protected learning especially valuable. It also strengthens the case for preserving the state of knowledge and dissent at the time of commitment so later evaluation does not confuse *ex ante* uncertainty with *ex post* clarity.

A critical juncture can itself be generated by earlier intervention. Capacity building, coalition formation, legal reform, infrastructure creation, or public recognition can accumulate until a previously latent transformation becomes reachable. Timing analysis should therefore consider *juncture preparation*: actions undertaken earlier whose main contribution is to create the relational or institutional conditions under which later structural change can occur.

11.16.4 Event Order and Generative Precedence

Within the present framework, event order is more fundamental than a total calendar sequence. The partial order records which modeled events precede others in the relevant historical, causal, generative, institutional, or procedural sense, while leaving some events incomparable. Calendar order is one optional projection of that richer structure. Generative precedence then identifies a particular class of order relation: an event, capacity, relation, or condition must be established before another event can have its intended practical function. Clock order and generative precedence can coincide, but they need not. An event can have an earlier timestamp yet be generatively irrelevant to a later transformation, while a slowly accumulated capacity can be a necessary predecessor even when no single calendar event marks its completion.

Definition 11.296 (Generative precedence). A practical object x has *generative precedence* over a practical object y within a specified intervention model when the intended generation, activation, legitimacy, reachability, or functioning of y materially depends on the prior establishment or transformation of x .

Generative precedence can involve capability, authority, trust, information, infrastructure, relation, representation, or institutional memory. A monitoring system can require common definitions before data become comparable. Delegated discretion can require competence and accountability pathways before it becomes safely usable. A participatory governance arrangement can require representation and translation

capacity before formal participation generates meaningful voice. These examples show why temporal design should reconstruct dependency rather than simply assign dates.

A *precedence graph* can represent such dependencies where a graph is analytically appropriate. Nodes represent intervention-relevant events or conditions, while directed edges encode model-specific precedence relations. In GR, a partial order is not merely a convenient relaxation of a calendar sequence; it is a natural representation of historical time whenever several events can remain unordered or only relational precedence is warranted. Antichains can represent sets of events with no modeled precedence relation among them, while down-sets preserve the event history relevant to a later transformation. A labeled 2-complex can enrich this representation when higher-order relational composition matters. This connects timing methodology directly to the partial-order and 2-complex models developed in Section 11.12.

Generative precedence is especially important for historical-relational subjects. An intervention can seek to transform a present capacity whose existence depends on earlier relations, institutions, or recognitional events. Direct intervention at the present manifestation may be fragile if the antecedent conditions that regenerate the capacity remain unchanged. Conversely, recreating an earlier condition can be inappropriate if the subject's historical trajectory has transformed the meaning of that condition. Precedence analysis therefore reconstructs dependency without assuming historical reversibility.

Definition 11.297 (Precedence remainder). A *precedence remainder* records unresolved, disputed, or weakly observed dependencies that may affect the proposed intervention sequence but cannot yet be assigned a stable precedence relation.

Preserving this remainder matters because a falsely precise sequence can be more dangerous than an explicitly incomplete one. Where precedence remains uncertain, staged intervention and monitoring can be designed to test or revise the dependency structure as praxis proceeds.

11.16.5 Order-Sensitive Operator Sequencing

Order-sensitive operator sequencing formalizes cases in which intervention composition is noncommutative. The practical configuration produced by applying transformation a and then transformation b can differ from the configuration produced by reversing their order. Section 11.12 introduced operator algebra as one possible representation of such order dependence. Timing methodology now uses that representation to design intervention sequences.

Equation 11.41 states the basic noncommutative case.

$$\Phi_b \circ \Phi_a \neq \Phi_a \circ \Phi_b. \quad (11.41)$$

Equation 11.41 compares two alternative admissible event orders rather than two points on a presumed universal clock. It has substantive meaning only when the operators and their domains are specified. The inequality can arise because the first transformation changes the domain, parameters, institutional authority, subject configuration, or action space on which the second transformation operates. The formal

expression should therefore be accompanied by a practical account of the mechanism generating the order effect.

One common form involves epistemic events. Observation followed by institutional recognition can differ from recognition followed by observation because recognition can alter reporting behavior, access, categories, or incentives before the observation occurs. Participation before design can generate options that would not exist if design were completed first. Pilot deployment before full authorization can produce evidence that changes later institutional criteria, while full authorization before a pilot can make subsequent evaluation politically or institutionally difficult to interpret.

Definition 11.298 (Sequence-effect profile). A *sequence-effect profile* records the compared intervention orders, the model or interpretation supporting order sensitivity, the practical mechanisms through which earlier events alter later transformations, affected positions, expected history-space effects, and uncertainty concerning the comparison.

Operator sequencing can also contain partial reversibility. If Φ_a changes a field in a way that enables Φ_b , reversing Φ_a after Φ_b may fail to restore the earlier configuration because Φ_b has already generated new relations or dependencies. Sequence design should therefore distinguish algebraic inverse notation from practical rollback. A formal inverse can be unavailable, approximate, or practically meaningless even when a technical reversal procedure exists.

Noncommutative sequencing does not imply that operator algebra is required for every intervention. Narrative, process-tracing, workflow, partial-order, simulation, or institutional models can represent the same substantive order dependence where they better fit the practical object. The formalism earns its place when composition rules clarify sequence effects that ordinary calendar description would obscure.

11.16.6 Temporal Coordination

Temporal coordination concerns alignment among interdependent actions occurring across actors, institutions, infrastructures, or timescales. Within an event-order representation, coordination can concern precedence, permitted concurrency, synchronization under an auxiliary clock, overlap, or deliberate separation. Events that are incomparable in the partial order are not thereby asserted to be simultaneous; they are simply left without a modeled precedence relation. Coordination methodology specifies these relations rather than assuming that every component can be independently scheduled on one common timeline.

Definition 11.299 (Temporal coordination profile). A *temporal coordination profile* records interdependent activities, responsible positions, required ordering or overlap, synchronization tolerances, communication interfaces, buffer capacity, fallback arrangements, and consequences of early, late, or missing coordination.

Coordination can be tight or loose. Tight synchronization can be necessary when a protective service, technical transition, legal authorization, and communication system must activate together. Loose coordination can be more robust when actors need autonomy to adapt locally or when synchronization failure would create a common-mode risk. Temporal design should therefore evaluate the consequences of coordina-

tion intensity rather than treating synchronization as inherently desirable.

Different timescales create additional problems. A fast operational process can depend on slow maintenance, training, institutional trust, ecological regeneration, or legal review. Optimizing the fast process can consume the slow capacity that sustains it. Conversely, slow institutional reform can fail to protect actors facing immediate harm. A *timescale coordination map* should therefore connect rapid interventions to the slower processes that enable, constrain, or absorb them.

Temporal coordination also has a power dimension. Actors with greater resources can often absorb delay, accelerate procedures, or synchronize around their own schedules. Others bear waiting costs, missed access, or participation burdens. A coordination plan should therefore record how timing burdens and flexibility are distributed. This is especially important when the institution organizing the process experiences delay as administratively convenient while affected subjects experience it as cumulative harm.

Coordination interfaces should include communication and state handoff. If one stage finishes but the next stage receives only a result rather than the assumptions, uncertainty, unresolved dissent, or maintenance requirements attached to that result, temporal continuity can conceal epistemic discontinuity. The practical handoff should therefore transmit both the intervention state and the provenance needed to interpret it.

11.16.7 Delayed Effects

Delayed effects arise when consequential events occur downstream of an intervention event through a nontrivial chain of ordered transformations, or when their clock-time manifestation is separated from the intervention by a substantial lag. Delay can result from accumulation, institutional learning, ecological processes, infrastructure depreciation, trust formation, network propagation, demographic turnover, legal implementation, or slow transformation of norms and expectations. Timing methodology should therefore distinguish event-order distance and dependency from clock-time duration.

Definition 11.300 (Delayed-effect profile). A *delayed-effect profile* records anticipated consequence types, expected latency, affected positions, propagation pathways, observability conditions, competing explanations, relevant timescales, and the review horizon required before a practical judgment should be treated as sufficiently mature.

Delayed effects can produce systematic evaluation errors. An intervention can appear successful because immediate indicators improve while maintenance capacity is being depleted. It can appear unsuccessful because beneficial institutional learning has not yet matured. It can distribute early benefits to one group and delayed burdens to another. Evaluation schedules should therefore be connected to the generative mechanism rather than selected solely for administrative convenience.

Where an order-compatible continuous-time embedding is substantively useful, a present observable can depend on earlier interventions through a model-specific response kernel. Equation 11.42 gives one such specialization.

$$Y_t^{(m)} = \int_0^\infty D^{(m)}(\tau) G^{(m)}(\omega_{t-\tau}, a_{t-\tau}, e_{t-\tau}) d\tau. \quad (11.42)$$

Equation 11.42 is a continuous-time specialization rather than the GR definition of temporal structure. The delay kernel $D^{(m)}$ requires locally justified semantics and estimation where quantitative use is intended. In event-ordered models, delayed consequence can instead be represented through chains, path lengths, precedence depth, or other relations on the partially ordered history. Many practical settings are better served by qualitative lag categories, historical reconstruction, event studies, or simulations.

Delayed effects also interact with reversibility. A process can remain easy to stop while its consequences continue propagating because earlier commitments created durable dependencies. Conversely, an action can be difficult to reverse while some of its measurable consequences remain delayed. A timing record should therefore distinguish *commitment latency*, *effect latency*, and *recovery latency*. These different temporal structures can imply different monitoring and rollback designs.

The possibility of delayed harm creates a responsibility horizon extending beyond immediate implementation. An institution that closes a project when the implementation period ends can leave later actors without records, monitoring capacity, or authority to respond. Delayed-effect analysis should therefore connect directly to the long-horizon responsibility and practical-closure architectures developed in Chapter 10.

11.16.8 Staged Intervention

Staged intervention divides a practical commitment into temporally ordered components whose continuation, modification, escalation, or termination depends on conditions observed during implementation. Staging can reduce exposure, preserve options, generate evidence, build capacity, and reveal sequence effects before deeper commitments are made. It is particularly useful where uncertainty is substantial and reversibility declines with commitment depth.

Definition 11.301 (Staged intervention architecture). A *staged intervention architecture* specifies a sequence of bounded commitments together with stage objectives, entry conditions, monitoring objects, review gates, continuation criteria, escalation and de-escalation pathways, rollback provisions, and the information that must be transferred between stages.

A stage should have genuine practical significance. Administrative phases that pre-authorize the full trajectory may preserve little learning or reversibility. A meaningful review gate retains authority and practical capacity to alter the subsequent path. Diagnostic, capability, pilot, protective, and coordination stages can therefore serve different functions and should carry correspondingly different evidence and continuation criteria. This connects staging to the reversible-commitment and escalation architectures developed in Section 11.10.

Staging also changes the field. Learning, investment, expectations, infrastructure, and reputational commitments can make a nominally reversible pilot difficult to withdraw. A *stage lock-in profile* should therefore record dependencies, sunk investments,

contractual commitments, and legitimacy claims that can transform a bounded stage into durable commitment.

Definition 11.302 (Stage lock-in profile). A *stage lock-in profile* records the practical mechanisms through which a bounded intervention stage can increase the cost, difficulty, or legitimacy burden of later revision, rollback, or exit.

Staging should also avoid transferring uncertainty burdens disproportionately. A pilot can protect the institution from large-scale commitment while concentrating experimentation risk on a small affected population. The stage architecture should therefore document who bears learning costs, who receives benefits, who can contest continuation, and how harms discovered during the stage will be repaired.

11.16.9 Adaptive Sequencing

Adaptive sequencing governs revision of the remaining intervention order as the practical field evolves. It extends staged intervention by allowing not only continuation or termination, but also reordering, insertion, removal, branching, or regeneration of later steps after new epistemic events, capacities, institutions, or consequences emerge. The sequence therefore becomes a revisable practical object rather than a fixed implementation schedule.

Definition 11.303 (Adaptive sequencing rule). An *adaptive sequencing rule* specifies the observations, epistemic events, capacity changes, consequence patterns, institutional conditions, or action-space transformations that can trigger revision of the remaining intervention order, together with the authority and provenance requirements governing that revision.

A model-specific sequence state can be represented by a planned partial order σ together with the currently realized event history $\mathcal{H}_{\text{real}}$, the practical configuration, and the epistemic state. Equation 11.43 gives a schematic update.

$$\sigma' = \mathcal{S}(\sigma, \mathcal{H}_{\text{real}}, \omega, e, \mathcal{A}, \mathcal{I}). \quad (11.43)$$

Equation 11.43 indicates that sequence revision can depend on the realized event structure, the transformed field, epistemic events, the updated action space, and institutional conditions. The revised σ' can change precedence relations, add branches, leave additional events unordered, or introduce clock-time constraints where operational synchronization requires them. Revision can be qualitative, participatory, computational, or hybrid according to the intervention.

Adaptive sequencing requires provenance. If a sequence $a \rightarrow b \rightarrow c$ changes to $a \rightarrow d \rightarrow b$, the record should preserve the trigger, justification for d , any changed meaning of b , and consequences for responsibility and evaluation. This prevents later reconstruction from treating adaptation as though it had been the original plan.

Definition 11.304 (Sequence revision record). A *sequence revision record* preserves the prior intervention order, triggering events or observations, revised precedence relations, inserted or removed stages, changes in expected consequences, responsible authority, remaining uncertainty, and implications for evaluation, rollback, and later learning.

Adaptive sequencing can also generate or foreclose actions. A stage that creates trust, knowledge, institutional memory, or technical capability can make a previously absent intervention reachable, while an adverse event can close a planned branch. The temporal architecture should therefore remain coupled to the action-space regeneration framework of Sections 11.7 and 11.10.

Proposition 11.305 (Temporal-generative intervention design). *Within the present framework, intervention timing is methodologically adequate when the practical design represents the event-order relations through which actions become reachable and consequential, and, where useful, their clock-time labels; it should also represent how precedence, concurrency, order-sensitive composition, and delay alter subject and institutional configuration, reversibility, learning, and the later intervention structure itself.*

The proposition completes the temporal layer of intervention design. Target selection identifies the practical objects to be changed; timing and sequencing identify the temporal relations through which change is attempted. Section 299 next develops scale selection, historical-relational resolution, coarse-graining, and scale translation before intervention depth is specified.

11.17 Scale Selection

Section 11.15 distinguished layers at which intervention can be targeted, while Section 11.16 developed the event-ordered temporal architecture within which interventions are sequenced. The present section addresses a different design problem: the scale and resolution at which a practical configuration should be represented, governed, and transformed. Its role within Chapter 11 is to prevent intervention design from silently assuming that the scale at which a problem becomes visible is also the scale at which it is generated, governed, or repairable. Its objective is to develop a multiscale methodology spanning individual, interpersonal, organizational, community, institutional, and field-level praxis while also distinguishing practical scale from historical and relational resolution. The discussion proceeds through scale-specific analysis, multiscale coupling, coarse-graining, scale translation, and the diagnosis of scale mismatch.

Definition 11.306 (Practical scale). A *practical scale* is a model-relative level of organization, interaction, authority, or consequence at which actors, relations, events, capacities, institutions, or fields are represented for diagnosis, decision, intervention, monitoring, or evaluation.

Definition 11.307 (Representational resolution). *Representational resolution* is the granularity with which a practical model distinguishes events, relations, subjects, histories, spatial or institutional positions, and transformation pathways within a selected scale.

Scale and resolution should remain distinct. An organizational-scale analysis can be coarse, representing only formal departments and aggregate flows, or fine, representing particular roles, event sequences, interfaces, and historical dependencies. Conversely, a fine-grained event history can span several organizational or institutional scales. The distinction is especially important under the event-ordered temporal architecture developed in Section 11.16: increasing temporal resolution need

Table 11.17: Scale-selection dimensions in applied praxis.

Scale or resolution	Primary analytical object	Characteristic design question
Individual	Historical-relational subject, capability, standing, internal organization	Which subject-level capacities or conditions are practically transformable?
Interpersonal	Dyads and small relational configurations	Which relations of dependence, trust, care, authority, or exchange mediate the problem?
Organizational	Roles, routines, workflows, interfaces, collective capacity	Which organizational processes reproduce or can transform the practical condition?
Community	Shared practices, membership, local infrastructures, collective memory	Which locally constituted relations and capacities support or constrain collective praxis?
Institutional	Rules, mandates, authority, durable classifications, accountability	Which durable arrangements govern admissible action and responsibility?
Field	Distributed relations across organizations, institutions, and positions	Which wider topology, incentives, dependencies, or distributed conditions shape local trajectories?
Historical / relational resolution	Events, precedence, relations, branches, internal structure	Which distinctions must remain visible for the relevant generative mechanism to be represented?
Multiscale	Coupled transformations across several scales	Which scale interactions must be coordinated rather than treated independently?
Coarse-graining / translation	Maps between finer and coarser representations	Which information and generative structure survive translation across resolutions?
Scale fit	Alignment among target, mechanism, authority, observation, consequence, and repair	Where does a mismatch among practical scales distort intervention design?

not mean subdividing a scalar clock interval; it can mean distinguishing additional events, precedence relations, branches, and relational dependencies within a partial order.

Scale selection also need not imply a single nested hierarchy. Individuals participate in several organizations, communities can cross institutional jurisdictions, fields can connect actors located in different organizations and territories, and one historical-relational subject can itself contain internally differentiated scales. Practical scales can therefore overlap, intersect, and partially embed one another. The methodological task is to specify which scale relations are being represented rather than to presume a universal micro–macro ladder.

Table 11.17 summarizes the section’s scale architecture. The table is not a hierarchy of increasing importance. Each scale can become analytically primary depending on the problem, and practical adequacy often depends on preserving interfaces among several scales.

11.17.1 Individual Scale

Individual-scale intervention concerns the practical configuration of a person or another analytically individuated subject. Within GR, however, the individual should not be presumed to be an isolated point bearing fixed preferences or capacities. Sections 11.7 and 11.12 treated subjects as potentially historical-relational objects whose present configuration can contain internal organization, accumulated events, institutional positions, classifications, capacities, commitments, and relations to other subjects. Scale selection therefore asks what can responsibly be represented at the individual scale while preserving the relations through which the individual has been constituted.

Definition 11.308 (Individual-scale practical profile). An *individual-scale practical profile* records the subject-level capacities, constraints, internal organization, historical events, institutional positions, relations, available actions, and relevant uncertainty that materially shape the practical problem at the selected level of individuation.

Individual-scale methods can be appropriate when intervention targets a subject's capability, knowledge, health, skill, practical autonomy, recognized standing, internal coordination, or another subject-level condition. They are also useful when actors occupying similar structural positions nevertheless follow different trajectories because their histories, internal resources, or relational configurations differ. The scale becomes analytically weak when it absorbs into the individual mechanisms that operate primarily through institutions, fields, infrastructures, or relations among subjects.

An individual-scale representation should therefore include an *external-relational boundary*. The boundary records which relations and institutional conditions remain outside the subject model but materially affect the subject's options or consequences. This makes visible the degree to which an apparently individual target depends on a wider practical architecture. For example, capability formation can be modeled at the subject scale while the opportunity to exercise that capability depends on organizational authorization or field-level access.

Individual scale also raises a resolution question. A subject can be represented coarsely through a few state variables, or more richly through an event-ordered historical structure. Where a subject's continuity and capacity depend on a sequence of formative events, a partial-order or labeled 2-complex representation may preserve distinctions that a point-state representation removes. The model should become more detailed only where the additional resolution changes diagnosis, intervention design, or responsibility.

11.17.2 Interpersonal Scale

Interpersonal-scale analysis takes relations among a small number of subjects as the primary practical object. The relevant relation can concern trust, care, communication, authority, dependency, recognition, exchange, conflict, learning, or another interaction whose properties are not reducible to the separate attributes of the participating subjects. This scale is especially important where the mechanism of change

lies in the relation itself.

Definition 11.309 (Interpersonal intervention scale). An *interpersonal intervention scale* represents a bounded configuration of relations among subjects as the primary locus of practical diagnosis or transformation while retaining the subject histories and wider institutional conditions needed to interpret those relations.

Interpersonal relations can be asymmetric. A relation of dependence can give one subject greater capacity to delay, exit, define the problem, or impose uncertainty on another. A trust relation can permit coordination while simultaneously concentrating vulnerability. An intervention that changes one subject's behavior without changing the relation can therefore leave the generative mechanism intact. Conversely, relational redesign can alter both subjects even where neither is directly targeted as an isolated entity.

This scale also allows practical analysis of reciprocal and circular effects. Recognition by one subject can alter another subject's self-understanding, which can alter subsequent interaction. Communication can generate new shared categories that change later observations. These are naturally represented as event-ordered relational processes rather than as independent updates to fixed individual states.

Interpersonal analysis should nevertheless avoid assuming that all relational problems can be solved at the dyadic scale. A relation can be generated or stabilized by organizational roles, legal classifications, economic dependence, or field-level norms. The method should therefore record which interpersonal properties are locally transformable and which are inherited from wider scales.

11.17.3 Organizational Scale

Organizational-scale intervention concerns coordinated systems of roles, routines, workflows, authority, information, resources, and internal interfaces. Organizations can generate collective capacities that no single member possesses, while also producing bottlenecks, memory loss, coordination failure, or concentrated authority. The organizational scale is therefore more than an aggregation of individuals.

Definition 11.310 (Organizational-scale configuration). An *organizational-scale configuration* is a practical representation of roles, authority, routines, interfaces, resources, information flows, memory structures, and collective capacities through which an organization produces and revises action.

Scale selection at this level asks whether the practical mechanism is reproduced through organizational arrangement. A recurring failure can arise because information does not cross departmental boundaries, because responsibility is fragmented across interfaces, because formal authority is disconnected from implementation capacity, or because institutional memory is lost during personnel turnover. These mechanisms cannot be reconstructed adequately by summing individual traits.

Organizational intervention can target internal topology. It can alter role distribution, decision rights, escalation pathways, information interfaces, maintenance routines, or memory handoffs. It can also generate new collective capabilities through coordination and trust. Such changes often have event-order effects: training before delegation can produce a different organizational history from delegation before

training; protected reporting before evaluation can generate different evidence from evaluation before reporting protections exist.

The organizational scale can conceal internal heterogeneity if used too coarsely. A single organizational node in a field-level network can contain multiple positions with conflicting interests, unequal exposure, and distinct knowledge. When these differences materially affect intervention, the representation should reopen the organization and increase resolution rather than treating it as an indivisible actor.

11.17.4 Community Scale

Community-scale analysis concerns practical configurations organized through shared locality, practice, identity, infrastructure, history, association, or other forms of collective relation that do not necessarily coincide with formal organizational boundaries. The term *community* should therefore identify a model-specific relational configuration rather than presume homogeneity, consensus, or fixed membership.

Definition 11.311 (Community-scale practical configuration). A *community-scale practical configuration* is a bounded and revisable representation of shared practices, relations, infrastructures, collective memory, local knowledge, membership conditions, internal differences, and external interfaces that materially shape collective praxis.

Community scale can be important when local knowledge, informal support, shared infrastructure, repeated interaction, or collective memory generates practical capacity unavailable through formal institutions alone. It can also reveal burdens that disappear in administrative aggregates. Participatory mapping and local-knowledge methods developed in Sections 11.13 and 11.14 can therefore be especially useful at this scale.

Community boundaries can themselves be contested or generated through intervention. Recognition, funding, legal designation, infrastructure, or participatory procedures can stabilize one membership boundary and weaken another. A community intervention can therefore change the practical object it claims merely to support. A *community-boundary record* should preserve the criteria, contributors, exclusions, overlaps, and revision conditions through which the represented community was defined.

Internal heterogeneity remains central. A community can contain unequal authority, unequal ability to participate, divergent histories, and competing interpretations. Community-scale analysis should therefore preserve intra-community relations where they are materially relevant rather than treating a collective label as evidence of shared interest.

11.17.5 Institutional Scale

Institutional-scale intervention concerns durable rules, classifications, mandates, authority structures, procedures, expectations, and accountability arrangements that organize practical possibility across repeated cases and actors. Institutions can span several organizations and persist through turnover in individual participants. Their

effects are therefore often temporally and organizationally distributed.

Definition 11.312 (Institutional-scale intervention). An *institutional-scale intervention* targets the durable rules, mandates, classifications, procedures, authority relations, accountability pathways, or memory structures through which repeated practical situations are organized.

This scale is appropriate when local variation is generated by a common institutional architecture. Repeated burdens can arise from one classification rule, authorization procedure, reporting standard, or allocation logic even when implementation occurs through many organizations. Institutional intervention can therefore transform the conditions under which local actors act rather than instructing each actor separately.

Institutional scale also requires attention to enactment. Formal rules can differ from operational practice, and informal adaptations can become the effective institution. Section 11.2 distinguished formal design from enacted institutional configuration. Scale selection should carry that distinction forward: a formal institutional target can be too coarse if the practical mechanism lies in local interpretation, implementation routines, or interface practices.

Institutional change can have long event-order consequences. A classification introduced at one historical moment can shape later data, recognition, resource access, and organizational routines. The intervention therefore affects not only present rules but also the future epistemic events through which the field becomes represented. Institutional-scale evaluation should retain this historical propagation rather than treating reform as a single-date rule change.

11.17.6 Field Scale

Field-scale analysis represents distributed relations extending across multiple organizations, institutions, communities, infrastructures, or positions. The relevant practical object can include flows of authority, knowledge, resources, legitimacy, risk, dependency, standards, or opportunity that cannot be localized to one institutional unit. A field is therefore defined by the relational structure represented, not simply by territorial size.

Definition 11.313 (Field-scale practical representation). A *field-scale practical representation* models distributed relations, positions, flows, constraints, opportunities, and transformation conditions across multiple organizational or institutional loci whose interaction materially shapes the practical trajectory.

Field-scale methods are useful when local interventions repeatedly encounter the same wider incentives or dependencies. An organization can change its internal procedure yet remain constrained by external standards, resource flows, professional norms, infrastructure, or concentrated gatekeeping. Conversely, a field-level reform can fail if it assumes organizations possess local capacities they do not have.

Fields can be represented through networks, higher-order structures, distributed fields, institutional maps, historical narratives, or mixed models. The representation should preserve the mechanism relevant to intervention. A network can show topology while concealing meaning; a field representation can show distributed intensity

while concealing organizational authority; an institutional narrative can preserve meaning while offering limited quantitative resolution. Method plurality therefore remains necessary at this scale.

Field-scale intervention also raises distributional questions. A change that improves aggregate coordination can concentrate vulnerability in one position or transfer maintenance burdens across organizations. Field-scale robustness should therefore be assessed together with the cross-scale and justice architectures developed earlier in the chapter and in Chapter 10.

11.17.7 Historical and Relational Resolution

Historical and relational resolution concerns how finely a representation distinguishes the events and relations through which a practical configuration has been formed. This dimension should remain separate from organizational or institutional scale. A field-level model can use fine event resolution, while an individual-scale model can remain coarse. The appropriate resolution depends on which distinctions materially affect the generative mechanism, decision, or evaluation.

Definition 11.314 (Event-relational resolution). *Event-relational resolution* is the granularity with which a model distinguishes events, precedence relations, relational types, subject boundaries, branches, and higher-order compositions within a represented practical history.

Under the temporal architecture of Section 11.16, increasing historical resolution does not require subdividing a universal scalar timeline. It can instead mean distinguishing previously aggregated events in the partial order, identifying a new precedence relation, separating one relation into several typed relations, or resolving a coarse subject into an internally structured historical-relational object. The refinement is warranted when these distinctions change inference or intervention design.

Resolution also affects causal and normative attribution. A coarse representation can make one institutional decision appear to produce a later consequence directly, while a finer event structure reveals intervening adaptation, translation, resistance, or additional decisions. Conversely, excessive resolution can make a stable higher-order pattern difficult to see. The objective is therefore neither maximal detail nor maximal aggregation, but preservation of the distinctions needed for the practical question.

Definition 11.315 (Resolution adequacy profile). A *resolution adequacy profile* records which events, relations, subject boundaries, historical dependencies, and higher-order structures are distinguished at the current resolution, which are aggregated, and what practical claims depend on those choices.

Resolution can itself change during praxis. A new epistemic event can reveal that a formerly adequate aggregate category contains materially different substructures. Monitoring can discover that one “implementation stage” actually contains several order-sensitive events. Conversely, repeated evidence can justify aggregation where finer distinctions no longer alter the practical judgment. Resolution should therefore remain versioned and revisable.

11.17.8 Multiscale Intervention

Multiscale intervention coordinates transformations at more than one practical scale when the generative mechanism crosses scale boundaries. Such intervention is not equivalent to applying several independent interventions simultaneously. The relevant issue is how transformations at different scales enable, constrain, amplify, absorb, or counteract one another.

Definition 11.316 (Multiscale intervention architecture). A *multiscale intervention architecture* specifies the practical scales involved, the intervention object at each scale, cross-scale dependencies, direction of influence, temporal ordering, authority, information interfaces, expected feedback, and conditions for coordinated revision.

A subject-level capability programme can fail when organizational roles leave no opportunity to exercise the capability. An institutional reform can fail when organizations lack implementation capacity. A field-level standard can create local compliance without changing the interpersonal relation that generates harm. These cases show why cross-scale coupling should be represented before intervention depth or mechanism is fixed.

Cross-scale influence can move in several directions. Higher-scale arrangements can condition local possibilities through rules, resources, infrastructure, or categories. Local innovation can propagate upward through learning, coalition formation, replication, or institutional revision. Repeated interpersonal interaction can generate community norms, while field-level narratives can alter interpersonal expectations. Multiscale methodology should therefore avoid a one-directional micro-to-macro or macro-to-micro assumption.

The event-ordered temporal architecture is useful here because scale interactions can have precedence without sharing one common clock. Organizational readiness can be a predecessor of institutional delegation; local evidence can precede field-level standard revision; a field-level recognition event can precede organization-level implementation. A multiscale history can therefore be represented through partially ordered events carrying scale labels rather than through one sequence of synchronized aggregate states.

Definition 11.317 (Cross-scale coupling record). A *cross-scale coupling record* documents a represented dependency or feedback between practical scales, including the events or relations that mediate the coupling, its direction, uncertainty, temporal structure, affected positions, and implications for intervention coordination.

Multiscale intervention also requires division of responsibility. The actor capable of changing a local relation may lack authority over the institutional rule generating it. The institution capable of changing the rule may lack local knowledge required for implementation. Effective architecture therefore aligns scale-specific authority and capacity while retaining interfaces for learning and contestability.

11.17.9 Coarse-Graining and Scale Translation

Coarse-graining constructs a lower-resolution representation from a more differentiated practical configuration. Scale translation connects objects or claims across representations that differ in scale or resolution. Both operations can be useful, but nei-

ther is epistemically neutral. Aggregation can preserve some structures while erasing others, and translation can preserve practical correspondence without establishing identity between the represented objects.

Definition 11.318 (Practical coarse-graining). A *practical coarse-graining* is a documented transformation from a finer practical representation to a coarser representation that specifies which events, relations, subject distinctions, histories, or local variations are merged, summarized, or omitted and which practical properties are intended to remain interpretable after the transformation.

For event-ordered histories, a coarse-graining can be represented by an order-preserving map between partially ordered event sets. Equation 11.44 gives one model-specific form.

$$q : (\mathcal{E}, \preceq) \longrightarrow (\bar{\mathcal{E}}, \bar{\preceq}), \quad e_1 \preceq e_2 \implies q(e_1) \bar{\preceq} q(e_2). \quad (11.44)$$

Equation 11.44 requires order preservation for precedence relations that the coarse representation claims to retain. The map can merge several fine events into one coarse event or omit distinctions irrelevant to the current task. Other coarse-graining schemes can be appropriate where the represented object is a network, field, organization, probability model, or narrative history.

Coarse-graining becomes especially informative when combined with transformation. If a fine-scale intervention operator is Φ and the corresponding coarse representation uses $\bar{\Phi}$, the relation in Equation 11.45 provides one test of scale consistency.

$$q(\Phi(\omega)) \stackrel{?}{=} \bar{\Phi}(q(\omega)). \quad (11.45)$$

Equation 11.45 is not expected to hold universally. Approximate agreement can indicate that the coarse model preserves the intervention-relevant transformation over the stated domain. Systematic nonagreement can reveal that aggregation removes interaction, threshold, history, or heterogeneity effects necessary for the practical claim. The failure to commute can therefore be diagnostically valuable rather than merely a technical defect.

Definition 11.319 (Scale-translation remainder). A *scale-translation remainder* records events, relations, meanings, heterogeneity, path dependence, uncertainty, or normative differences that materially affect practical interpretation but are not preserved by the selected coarse-graining or cross-scale translation.

Scale translation should preserve provenance. A field-level indicator derived from organization-level records should retain enough information to reconstruct how local categories were aggregated. A community narrative translated into an institutional classification should record what meanings were compressed or transformed. A subject-level effect inferred from aggregate data should identify the assumptions required for that movement across scale. This prevents practical conclusions from acquiring false universality merely because the path of translation has been forgotten.

11.17.10 Scale Mismatch

Scale mismatch arises when the scale at which a problem is represented, governed, observed, acted upon, or evaluated does not align sufficiently with the scale at which the relevant generative mechanism or consequence operates. Mismatch is therefore relational: there is no universally correct scale independent of the practical task.

Definition 11.320 (Scale-mismatch profile). A *scale-mismatch profile* compares the scales of problem representation, target, generative mechanism, authority, capability, observation, consequence, evaluation, and repair, and records where their misalignment materially distorts reachability, attribution, implementation, burden distribution, or revision.

Several recurrent forms can be distinguished. A *target-mechanism mismatch* occurs when intervention is directed at one scale while the mechanism generating the condition lies mainly at another. An *authority-problem mismatch* occurs when the responsible actor lacks jurisdiction over the relevant scale. An *observation-consequence mismatch* occurs when monitoring captures local short-run effects while consequences propagate across wider or slower structures. A *repair mismatch* occurs when harm is generated systemically but remedy is assigned to individual actors. A *resolution mismatch* occurs when the representation is too coarse or too fine to preserve the structure needed for practical inference.

Scale mismatch can also be generated by intervention. A local pilot can create a field-level standard. A field-level classification can individualize responsibility for a structural condition. An institutional reform can push unresolved burden into community or interpersonal relations. Evaluation should therefore ask how intervention redistributes practical problems across scales rather than assuming that successful change at the focal scale resolves the wider trajectory.

Mismatch does not automatically imply that the intervention should be moved to the largest scale available. Wider intervention can weaken local adaptation, exceed legitimate authority, obscure heterogeneity, or create coordination burdens. A practical response can instead involve multiscale coordination, changed representation, delegation, interface design, capability formation, or altered sequencing. The appropriate correction depends on the specific relation among scales.

Proposition 11.321 (Scale-selection adequacy). *Scale selection is practically adequate to the extent that the chosen representation preserves the actors, relations, events, historical dependencies, authorities, consequences, and cross-scale couplings needed for the intervention claim, while its coarse-graining and translation choices remain explicit, revisable, and proportionate to the decision task.*

Proposition 11.321 connects scale selection to the larger methodological architecture of this chapter. Scale should be selected with the target, history, model, timing, authority, uncertainty, and evaluation object in view. The resulting scale architecture can remain plural: different components of one intervention may require different scales and resolutions, provided the interfaces among them are represented and governed.

Scale selection still does not determine how deeply intervention should transform the selected object. A change at institutional scale can be shallow, modifying one parameter or procedure, or deep, altering the generative rule by which later institu-

tional states are produced. The next section therefore turns from the location and resolution of intervention to *intervention depth*.

11.18 Intervention Depth

Sections 11.15–11.17 specified the target, temporal architecture, and scale of intervention. The present section addresses a different design dimension: how far intervention should reach into the generative organization of the practical configuration. Its role within Chapter 11 is to distinguish interventions that stabilize manifestations or current states from interventions that transform relations, historical-relational subjects, structures, constraints, capacities, institutions, observation regimes, or the rules by which later histories are generated. Its objective is to make intervention depth explicit enough that practical ambition, epistemic burden, legitimacy, reversibility, and possible generative consequence can be evaluated together. The discussion proceeds from surface and state intervention through progressively more generative layers, while treating depth as multidimensional and model-relative rather than as a universal ladder of increasing desirability.

Definition 11.322 (Intervention depth). *Intervention depth* is the extent to which an intervention is intended to modify the represented conditions, relations, subject configurations, structures, capacities, institutions, observation regimes, or generative rules through which later practical states and histories are produced.

Definition 11.322 concerns the represented generative architecture rather than physical penetration, organizational size, budget, or political visibility. An intervention can be large in scale yet shallow in depth if it repeatedly changes current outputs while leaving the generative structure largely intact. A small intervention can be deep if it changes a classification, permission rule, relation, or institutional interface that reorganizes many later possibilities. Depth is therefore indexed to the model and the practical mechanism under consideration.

Intervention depth should also remain distinct from intervention target. The same target can be addressed at different depths. An institution can be targeted by changing one administrative output, one current state, a recurring relation among roles, its internal capacity, its mandate, or the rule by which later decisions are generated. Conversely, one intervention can couple several depths simultaneously. The methodological task is to identify which layers are intentionally transformed, which are expected to change only as consequences, and which should remain protected from unnecessary intervention.

Definition 11.323 (Intervention-depth profile). An *intervention-depth profile* records the represented layers intentionally transformed by an intervention, the layers expected to change indirectly, the generative mechanism connecting them, the expected persistence and reversibility of those changes, the affected positions, the epistemic and institutional requirements for acting at that depth, and the conditions for revision or withdrawal.

Table 11.18 summarizes the section's depth architecture. The rows should not be read as a universal sequence through which every intervention must proceed. They identify analytically different transformation objects. A practical design can combine

Table 11.18: Intervention-depth layers in applied praxis.

Depth layer	Primary transformation object	Characteristic concern	methodological
Surface	Manifested condition, interface, or immediate exposure	Stabilization, protection, relief, and preservation of later options	
State	Current configuration within a relatively stable generative rule	Persistence, recurrence, and dependence on unchanged dynamics	
Relational	Relations among subjects, positions, or components	Reciprocity, asymmetry, dependency, trust, authority, and spillovers	
Historical-relational subject	Subject configuration, standing, capability, internal organization, or event history	Agency, consent, continuity, path dependence, and subject transformation	
Structural	Recurrent topology or organization of relations and positions	Reproduction mechanisms, cross-scale effects, and structural persistence	
Constraint	Conditions limiting or shaping reachable actions and histories	Protective versus restrictive functions and constraint substitution	
Capacity	Ability to sense, decide, coordinate, act, maintain, repair, or revise	Activation pathways, sustainability, distribution, and capability decay	
Institutional	Mandates, roles, routines, accountability, memory, and durable coordination	Legitimacy, implementation, institutional transition, and handoff	
Observation and representation	Categories, indicators, measurement, visibility, and interpretive regimes	Performative epistemic effects, classification power, and representation error	
Rule	Transformation, update, permission, or composition rules	Wide downstream consequence, path dependence, and governance of rule revision	
Depth risk	Cross-layer consequence generated by deep intervention	Irreversibility, model error, legitimacy, capture, option loss, and repair capacity	

several rows, and an intervention can become deeper through one dimension while remaining shallow through another. The relevant question is whether the selected depth fits the represented generative mechanism and the practical conditions for responsible action.

11.18.1 Surface Intervention

Surface intervention acts principally on a manifested condition, interface, exposure, or immediate practical consequence while leaving the deeper represented generative architecture largely unchanged. The term *surface* is descriptive rather than dismissive. Immediate stabilization, protection, relief, access provision, containment, or temporary substitution can be practically decisive even when the conditions generating the problem remain in place.

Definition 11.324 (Surface intervention). A *surface intervention* is an intervention

whose primary intended effect is to alter a manifested condition, immediate exposure, practical interface, or short-horizon consequence without requiring substantial transformation of the represented relations, structures, institutions, or generative rules producing that condition.

Surface intervention is often appropriate where harm must be reduced before a deeper diagnosis is complete. It can preserve life, safety, continuity, access, or organizational function while research and deliberation continue. It can also create a possibility window for deeper intervention by reducing urgency, stabilizing a volatile relation, or protecting the capacities required for later participation. Surface intervention therefore has a potentially generative role even when its focal object is immediate manifestation.

The principal methodological risk is recurrence. If the underlying relations and generative conditions remain stable, the manifested problem can return after the surface intervention ends. Repeated surface intervention can then become an implicit maintenance regime. Such a regime may be appropriate when deeper transformation is infeasible, illegitimate, or more harmful, but its recurrent costs and dependencies should be represented explicitly rather than interpreted as evidence that the underlying problem has been resolved.

Surface interventions can also change the field indirectly. Temporary relief can alter expectations, trust, dependency, political attention, or institutional responsibility. A short-term substitute can become a durable infrastructure. A provisional category can become normalized. The depth profile should therefore distinguish the intervention's intended focal depth from consequential changes generated elsewhere in the practical configuration.

A useful design question at this layer is whether the intervention preserves later agency. Surface action can narrow future possibilities if it consumes scarce capacity, establishes lock-in, suppresses diagnostic signals, or converts a temporary response into an unexamined permanent arrangement. Conversely, it can expand later action space by buying time, protecting affected subjects, and maintaining reversibility. Surface intervention should therefore be evaluated through both immediate consequence and the options it leaves available for later praxis.

11.18.2 State Intervention

State intervention changes the current configuration of a represented system while treating the generative rule or transformation architecture as sufficiently stable for the practical task. The distinction from surface intervention is analytical. A surface intervention can modify only a manifested interface, whereas a state intervention can alter variables or configuration components that matter directly to later evolution even though the rule generating subsequent transitions remains unchanged.

Definition 11.325 (State intervention). A *state intervention* is an intervention that changes selected components of the current practical configuration while leaving the represented transformation rule, institutional grammar, or generative architecture approximately fixed over the intervention horizon.

State intervention is natural in models where a current configuration can be dis-

tinguished from the rule under which it evolves. Examples include changing a resource stock, staffing level, reserve, access condition, buffer, current allocation, or other state component while assuming that the relations and update mechanisms governing later change remain approximately stable. This can be a powerful and appropriate approximation where the practical horizon is bounded and the generative rule is empirically stable enough for the decision.

The methodological question is how rapidly the altered state is expected to decay, reproduce itself, or be absorbed by unchanged dynamics. A state intervention can produce a durable trajectory change if the new state crosses a threshold, enters another basin, creates a capability, or changes later event reachability. It can also disappear quickly if existing relations and institutions restore the earlier configuration. The distinction should be diagnosed rather than inferred from the apparent magnitude of the initial state change.

State intervention also interacts with event-ordered time. The same state change can have different consequences depending on the historical position at which it occurs. A resource injection before institutional authorization can be unusable, while the same injection after authorization can activate a new branch of action. State intervention should therefore retain the precedence and relational conditions through which a current-state change becomes generatively effective.

Repeated state interventions can reveal a deeper mismatch. If maintaining an acceptable configuration requires recurrent external correction, the method should ask whether the relevant mechanism lies in relations, constraints, capacities, institutions, or rules. The appropriate conclusion is not automatically to intervene more deeply. Recurrent correction can remain preferable where deeper transformation carries disproportionate uncertainty or legitimacy cost. The recurrence nevertheless becomes diagnostic evidence about the limits of the state-level strategy.

11.18.3 Relational Intervention

Relational intervention changes the relation through which subjects, positions, organizations, or other practical objects affect one another. The focal object is therefore not an isolated entity but a dependency, authority relation, exchange relation, trust relation, information interface, recognition relation, care relation, coordination relation, or other typed connection whose organization contributes materially to the practical trajectory.

Definition 11.326 (Relational intervention). A *relational intervention* is an intervention whose primary intended transformation concerns the existence, type, direction, intensity, accessibility, reciprocity, or governance of relations among practical positions.

Relational intervention can change later possibilities even when the attributes of the participating subjects remain initially unchanged. Altering an information interface can redistribute knowledge. Changing an authorization relation can redistribute practical power. Creating a trusted communication channel can generate coordination capacity. Reducing a dependency can make exit or refusal reachable. These consequences illustrate why relational depth differs from state depth: the intervention changes the pathway through which later states are produced.

Relations can be multiplex. Two positions can simultaneously exchange resources, share information, depend on one another, and occupy an asymmetric authority relation. An intervention that improves one relation can worsen another. Increasing information flow can strengthen coordination while also increasing surveillance. Strengthening accountability can increase answerability while generating administrative burden. The relational target should therefore retain relation type and practical meaning rather than reducing every edge to one scalar intensity.

Relational intervention can also generate new subjects or collective agency. Repeated coordination, mutual recognition, shared vocabulary, or durable collaboration can create a collective capacity that did not previously exist. Conversely, severing a relation can dissolve a previously coherent collective subject. These possibilities connect relational depth to the historical-relational subject architecture developed in Sections 11.7 and 11.13.

The principal governance issue is asymmetry. A relation can be changed by an actor who controls only one endpoint or by an institution whose authority covers some participants more strongly than others. Relational intervention should therefore record affected positions, authority, consent where relevant, exit conditions, and possible redistribution of burden or dependency. A relation that is efficient from one position can be constraining from another.

11.18.4 Historical-Relational Subject Intervention

Historical-relational subject intervention concerns changes to the practical configuration of a subject understood as an event-extended relational object rather than as a point bearing fixed attributes. Its inclusion requires particular care because intervention on a subject can affect capability, recognized standing, internal organization, identity-relevant categories, external relations, and the historical continuity through which the subject participates in later praxis.

Definition 11.327 (Historical-relational subject intervention). *A historical-relational subject intervention* is an intervention that intentionally modifies a subject's capabilities, recognized standing, internal organization, constitutive relations, practical roles, or event-historical configuration in ways expected to alter the subject's later participation in the practical field.

The category includes supportive and enabling forms of intervention. Capability formation, restoration of standing, removal of disabling classification, repair of a damaged relation, creation of protected voice, or strengthening of internal coordination can all transform the subject's later action space. Subject-level intervention therefore need not mean direct manipulation of preference or identity. It can concern the relational conditions under which the subject can act, learn, refuse, coordinate, or revise its own orientation.

The historical dimension is essential. A subject's present configuration can contain accumulated commitments, injuries, skills, institutional positions, expectations, and recognized events. An intervention that appears equivalent at the level of present-state variables can have different consequences for subjects with different histories. Where a partial-order or labeled 2-complex representation is useful, subject intervention can be modeled as addition, removal, relabeling, or reorganization of event-

relational structure. Other historical or interpretive representations may be preferable where formal event structure would conceal meaning.

Subject intervention also raises a stronger legitimacy burden than many state interventions because the intervention can alter the conditions of agency through which future consent or judgment is expressed. A programme that builds capability can expand agency; a classification regime can narrow recognition and available actions; an institutional process can reshape self-understanding or dependency. The method should therefore distinguish support for agency from substitution for agency and preserve contestability where the intervention modifies subject standing or identity-relevant categories.

There is also a risk of mislocating structural problems within subjects. When the generative mechanism operates mainly through institutional rules, field-level incentives, exclusionary relations, or infrastructural constraints, attempting to transform the affected subject can reproduce the very asymmetry that generated the problem. Historical-relational subject intervention should therefore be paired with the scale-mismatch analysis of Section 11.17 and the target architecture of Section 11.15.

11.18.5 Structural Intervention

Structural intervention modifies recurrent organization among positions, relations, events, or flows that persists across particular local states. A structure can be represented as a topology, role configuration, recurring dependency pattern, higher-order relation, institutional arrangement, spatial organization, or another stable pattern through which local events are conditioned. Structural depth therefore concerns the organization that makes certain local states repeatedly likely, reachable, or difficult to escape.

Definition 11.328 (Structural intervention). A *structural intervention* is an intervention intended to transform a recurrent organization of positions, relations, flows, or dependencies whose persistence materially shapes multiple later practical states or histories.

Structural intervention differs from relational intervention by scope of organization rather than necessarily by scale. One relation can be changed without altering the wider structure in which similar relations are repeatedly generated. Conversely, modifying a structural interface can alter many local relations without targeting each one separately. The distinction is model-relative: the analyst should state what counts as recurrent organization and how the represented structure is connected to observed practical conditions.

A structural intervention can involve topology, access pathways, role distributions, coordination architecture, dependency concentration, infrastructure, or higher-order rules of association. Its effect can propagate widely because several local processes rely on the same structure. This wider reach increases both potential leverage and the cost of representational error. If the diagnosed structure is only a visible correlate rather than a generative mechanism, deep structural intervention can redistribute harm without resolving the practical condition.

Structures can also carry useful capacity. Repeated relations can support trust,

memory, specialization, care, redundancy, or rapid coordination. Intervention should therefore identify both the burdens and capabilities reproduced by the structure. A redesign that removes a harmful dependency while destroying local knowledge or repair capacity can produce a formally cleaner structure with lower practical generativity.

Structural intervention should also preserve historical provenance. Recurrent organization can be the cumulative result of earlier decisions and adaptations rather than one deliberately designed system. This can make reversal difficult: actors have invested, learned, and organized around the structure. A structural transition plan should therefore represent intermediate configurations, displaced functions, and the capacities required to maintain continuity while the structure changes.

11.18.6 Constraint Intervention

Constraint intervention changes conditions that limit, channel, protect, or otherwise shape the reachable actions and histories of practical subjects. The objective can be to remove a disabling constraint, weaken a bottleneck, create a protective boundary, or redesign how constraints are distributed across positions. The method should retain the dual character of constraints: they can restrict agency while also preserving safety, rights, reliability, coordination, or ecological and institutional integrity.

Definition 11.329 (Constraint intervention). A *constraint intervention* is an intervention that modifies a condition limiting or channeling practical reachability, including the creation, relaxation, redistribution, substitution, or redesign of that condition.

Removing one constraint can expose another. A formal authorization barrier can be removed while financial, informational, relational, or capability constraints continue to block effective action. The intervention should therefore use the constraint-configuration analysis developed in Section 11.2 rather than treating constraints as independent obstacles.

Constraint substitution is especially important. Relaxing a regulatory constraint can increase dependence on private gatekeeping. Removing a procedural burden can transfer verification work to affected subjects. Tightening a safety rule can reduce one risk while creating access barriers elsewhere. The appropriate unit of evaluation is therefore the transformed constraint configuration and its distribution, not only the focal constraint.

Protective constraints can be generative. A protected right, safety boundary, or procedural requirement can preserve trust and future participation. A reserve requirement can maintain reversibility. A limit on extraction can preserve regenerative capacity. Constraint intervention therefore should specify which restrictions are regarded as burdens, which are regarded as constitutive or protective, and how those interpretations were established.

Constraints can also be historical. A present restriction can persist because earlier investments, classifications, or institutional arrangements narrowed the action space. Constraint intervention can accordingly require work on the history or structure that sustains the restriction, rather than only its current manifestation. The depth profile should identify whether the focal constraint is directly modifiable or is an expression

of a deeper relation, structure, institution, or rule.

11.18.7 Capacity Intervention

Capacity intervention aims to create, restore, distribute, combine, or sustain the ability of subjects or institutions to perform practical functions. Relevant capacities include sensing, interpretation, deliberation, decision, coordination, implementation, maintenance, repair, learning, contestation, and revision. Capacity intervention is therefore generative by design: it changes what later actions can become reachable.

Definition 11.330 (Capacity intervention). A *capacity intervention* is an intervention intended to create, restore, distribute, combine, or sustain practical abilities through which subjects, collectives, or institutions can later recognize, choose, execute, maintain, repair, or revise action.

Capacity should remain distinct from resource possession. Resources can contribute to capacity, but they require activation through knowledge, authority, relations, infrastructure, timing, and coordination. A training programme can increase skill without creating opportunity to use it. New information can remain ineffective without decision rights. Funding can remain idle without implementation capability. The method should therefore identify the activation pathway through which the intervention is expected to become usable capacity.

Capacity intervention can also change power. Giving one position analytical capability, mobility, legal standing, technical infrastructure, or coordination resources can alter dependency and bargaining relations. Capacity distribution should therefore be evaluated together with participation, responsibility, and justice. A system that increases total capability while concentrating the ability to define problems or control infrastructure can become more productive and less contestable at the same time.

Capacity can decay. Skills atrophy, organizations lose memory, infrastructure requires maintenance, and trust can deteriorate. A capacity intervention should therefore specify maintenance and regeneration conditions rather than recording only initial acquisition. This is especially important for long-horizon praxis, where the capacity to adapt and repair can matter more than peak initial performance.

Capacity intervention can also be intentionally enabling rather than directive. Instead of determining a specific downstream action, it can expand the capability of affected subjects to generate, compare, and revise their own actions. Such interventions are especially relevant where uncertainty is deep or local knowledge is distributed. Their evaluation should include the future action-space effects they create, not only immediate task performance.

11.18.8 Institutional Intervention

Institutional intervention changes durable arrangements of mandate, role, authority, routine, accountability, memory, classification, and coordination through which collective praxis is organized. It can therefore alter both present behavior and the mechanisms by which later decisions are produced, implemented, reviewed, and remembered.

Definition 11.331 (Institutional intervention). An *institutional intervention* is an intervention intended to transform durable arrangements of mandate, authority, role, procedure, accountability, memory, classification, or coordination that organize repeated practical action across time.

Institutional intervention should distinguish formal design from enacted configuration. A revised mandate can leave routines unchanged. A new reporting procedure can generate extensive records without creating answerability. A participatory body can exist formally while lacking agenda-setting power or protected voice. Institutional depth therefore concerns changes in effective practical organization as well as formal rules.

Institutional transformation can have long historical reach because later actors inherit its records, categories, responsibilities, infrastructures, and default procedures. The event-ordered architecture is useful here: institutional change is often an extended history composed of authorization, implementation, adaptation, conflict, reinterpretation, maintenance, and later revision rather than a single dated event. Different branches can emerge when local organizations enact the same formal reform differently.

Institutional intervention can also redistribute practical memory. Merging organizations, changing reporting systems, outsourcing functions, or replacing a professional community can sever memory interfaces even while improving present efficiency. A transition plan should therefore preserve reasons, unresolved uncertainty, responsibility, and knowledge needed by later actors. Institutional forgetting can turn a reversible reform into effective lock-in because later subjects can no longer reconstruct the conditions under which reversal was contemplated.

The legitimacy burden also rises when institutional intervention changes who can decide for whom, who is recognized, or who bears accountability. Authorization, participation, representation, and contestability should therefore be part of the intervention design rather than post-hoc governance additions. The deeper the institutional transformation, the more important it becomes to specify whose practical standing is altered and through what authority.

11.18.9 Observation and Representation Intervention

Observation and representation intervention changes the categories, indicators, data practices, classifications, maps, models, visibility rules, or interpretive procedures through which a practical field becomes knowable and governable. This layer is especially important under the revised epistemic-event architecture because representations can become performative when their recognition or institutional uptake changes the field they describe.

Definition 11.332 (Observation-regime intervention). An *observation-regime intervention* is an intervention that modifies how practical events, subjects, relations, states, or histories are selected, classified, measured, represented, communicated, or made institutionally visible.

Changing an indicator can redirect organizational attention. Recognizing a previously invisible category can create standing or eligibility. A new map can expose a

dependency and enable coordination. A ranking can alter incentives and strategic behavior. A legal or administrative classification can generate rights and duties. These cases show why observation and representation can be relatively deep interventions even where the immediate material configuration appears unchanged.

The typed distinction from Section 11.4 should remain explicit. A readout maps a practical configuration into a representation. Institutional uptake can then couple that representation to a transformation of the field. The intervention can therefore concern the observation architecture, the coupling architecture, or both. Treating these stages as identical would obscure whether the change arose from improved knowledge, from performative recognition, or from the institutional transformation triggered by that recognition.

Representation intervention also carries risks of exclusion and stabilization. New categories can make previously invisible conditions legible while simultaneously fixing heterogeneous subjects into administratively convenient classes. Indicators can support accountability while narrowing attention toward what is measurable. Models can improve coordination while concentrating interpretive authority. The method should therefore record representation remainders, affected positions, and contestability pathways.

Observation regimes also change evidence production. Once actors learn how they are measured, behavior and reporting can adapt. A monitoring system can therefore create new epistemic events and alter later data-generating processes. This makes versioning essential: evidence produced before and after a representation intervention may not be directly comparable without reconstructing the changed observation regime.

11.18.10 Rule Intervention

Rule intervention changes the transformation, update, permission, composition, or admissibility rules through which later practical configurations are generated. Section 11.15 introduced rules as intervention targets. The present subsection places rule transformation within the depth architecture and clarifies why rule-level intervention often carries a larger downstream reach than changing one present state or relation.

Definition 11.333 (Rule-depth intervention). A *rule-depth intervention* is an intervention that intentionally changes a represented transformation rule, update procedure, permission structure, composition law, or admissibility condition governing how later practical states, actions, relations, or histories can be generated.

A rule-level change can affect many later events because it changes the conditions under which those events become reachable. Changing an eligibility rule can reorganize access across an entire population of later cases. Changing an algorithmic update rule can alter future classifications. Revising an institutional authorization process can redistribute decision power across subsequent histories. Modifying the composition order of interventions can change the field on which later transformations operate.

Rule intervention can also change the history space rather than merely reweight

histories already represented. A new permission can create branches that did not previously exist. A prohibition can foreclose an entire family of actions. A revised institutional process can generate new subject roles or new epistemic events. This is why rule depth connects directly to the history-space architecture of Sections 11.4–11.8.

The greater reach of rule intervention creates a demanding epistemic problem. Errors in a rule can propagate across many downstream cases before they become visible. Local success under one context may not justify field-wide rule revision where transportability is uncertain. Rule intervention should therefore make scope, validity region, monitoring, fallback conditions, and authority explicit. Staged or modular rule changes can sometimes preserve learning and reversibility better than immediate universalization.

Rule intervention also creates reflexive effects. Actors learn rules, reorganize around them, exploit them, resist them, and develop institutions specialized to them. The effective rule after adaptation can therefore differ from the formal rule initially enacted. Evaluation should include these co-evolutionary consequences rather than examining only whether implementation matched the original specification.

11.18.11 Deep Intervention Risk

Deep intervention can create large generative leverage because it changes conditions through which many later events and actions are produced. The same leverage can amplify diagnostic error, legitimacy failure, unintended consequence, path dependence, and loss of reversibility. Depth therefore creates a distinctive practical burden: the intervention reaches farther into the architecture that later actors inherit.

Definition 11.334 (Deep-intervention risk profile). A *deep-intervention risk profile* records the epistemic uncertainty, affected positions, reversibility, propagation pathways, option-space effects, institutional and subject transformation, legitimacy conditions, repair capacity, and possible long-horizon consequences associated with intervening at the selected generative depth.

Several risk dimensions deserve separate treatment. *Diagnostic depth risk* arises when the represented generative mechanism is mistaken. *Propagation risk* arises when a deep change spreads across relations or histories farther than intended. *Lock-in risk* arises when later subjects, institutions, and infrastructures adapt around the intervention. *Agency risk* arises when subject or institutional transformation alters the practical standing of those expected to contest or revise the intervention. *Epistemic risk* arises when the intervention changes the observation regime in ways that make its own consequences harder to detect. *repair risk* arises when the intervention removes the capacities required to reverse or compensate for harm.

Deep intervention can also destroy useful generativity together with harmful structure. A relation that reproduces dependency can simultaneously carry care or knowledge. An institution that imposes burdens can preserve memory and coordination. A rule that constrains access can also protect safety. A structural redesign can remove redundancy that appeared inefficient under the original performance metric. The intervention should therefore identify functions worth preserving and, where possible, create replacement capacity before dismantling the structure that currently provides

them.

The depth decision should be proportionate to practical warrant. Greater expected leverage increases the importance of mechanism evidence, affected-subject participation, authority, monitoring, reversibility, and repair capacity. Yet proportionality does not mean that deep intervention always requires complete knowledge. In urgent situations a deeper action can be justified where shallow alternatives cannot protect against severe and accumulating harm. The methodological requirement is to make the residual uncertainty and protection architecture commensurate with the depth of commitment.

Definition 11.335 (Depth proportionality). *Depth proportionality* is the alignment between the generative depth of an intervention and the strength of its diagnostic support, legitimate authority, participation, reversibility, monitoring, repair capacity, and protection of affected positions, given the consequences of both intervention and continued inaction.

Depth proportionality also leaves room for deliberately shallow design. A reversible state intervention can be preferable to a deep institutional reform when the mechanism remains uncertain. A temporary surface intervention can preserve affected subjects while participatory diagnosis continues. A capacity intervention can generate later options without prematurely fixing a rule. In other cases, repeated shallow interventions can accumulate into an opaque permanent regime and should be compared with a more explicit structural or institutional transformation. The relative merits depend on the practical field, not on an abstract preference for depth.

A final concern is *depth coupling*. An intervention intended at one depth can trigger changes at another. A representation intervention can become a rule intervention when a classification is embedded in authorization. A capacity intervention can become a relational intervention when newly capable actors renegotiate dependencies. A structural intervention can generate subject transformation through altered roles and histories. The depth profile should therefore be revised when consequential coupling crosses the original design boundary.

Proposition 11.336 (Intervention-depth adequacy). *Intervention depth is practically adequate to the extent that the selected depth corresponds to a defensible account of the generative mechanism, preserves or replaces valuable capacities carried by the transformed configuration, and is matched by proportionate authority, participation, uncertainty management, reversibility, monitoring, and repair arrangements.*

Proposition 11.336 closes the separation of target, timing, scale, and depth developed across Sections 11.15–11.18. These dimensions now provide inputs to a more integrated design problem. The next section therefore turns to *intervention design*, where objective, target, mechanism, epistemic-event architecture, enabling conditions, expected histories, monitoring, revision, and exit are assembled into one practical intervention architecture.

11.19 Situated Intervention Design

The role of this section is to specify intervention design at the meta-methodological level after target, timing, scale, and depth have been treated separately. Its objective

is to show how these dimensions can be composed into a context-sensitive practical architecture without turning one intervention template into a universal sequence. The discussion proceeds through situated composition, selective relevance of design dimensions, the relation among orientation, target, and mechanism, enabling and constraining conditions, effects on history and possibility spaces, embedded monitoring and revision, provenance and responsibility, and proportionate design depth. The method is architectural and plural: an intervention design can be formal, institutional, participatory, historical, legal, computational, qualitative, or mixed according to the practical field.

Intervention design is therefore understood as a problem of composition. Different fields require different design objects. A small reversible adjustment can require little more than a clearly specified action, responsible position, observation route, and stopping condition. A deep institutional transformation can require historical reconstruction, multiple mechanisms, participatory governance, legal authority, formal models, staged implementation, independent monitoring, repair capacity, and long-duration exit obligations. The framework should help identify which dimensions matter and how they are related; it should not force every intervention to fill the same checklist.

Definition 11.337 (Situated intervention design). A *situated intervention design* is a revisable composition of the practical orientations, intervention objects, mechanisms, timing, scale, depth, enabling conditions, constraints, anticipated histories, observation arrangements, responsibility relations, revision pathways, and exit conditions that are materially relevant to a specified intervention in its historical-relational field.

The phrase *materially relevant* is central. A design dimension belongs in the intervention architecture when omitting it would materially weaken practical understanding, accountability, protection, learning, or capacity for revision. The set of relevant dimensions can therefore differ across cases and can expand after the intervention begins.

Table 11.19 presents a repertoire of design dimensions. The table is not a mandatory form. Its function is to make possible interfaces visible so that a project can select and document those needed for its own field.

The repertoire in Table 11.19 also supports proportionality. A dimension can be represented lightly when consequence is small and strongly bounded. The same dimension can require extensive analysis when the intervention is deep, long-duration, difficult to reverse, distributively concentrated, or dependent on uncertain mechanisms.

11.19.1 Design as Situated Composition

A situated design begins with the practical field rather than with a preselected form. The field can already contain interventions, institutional routines, inherited obligations, competing authorities, affected subjects, and historical dependencies. Designing action therefore often means composing a change into an existing architecture rather than creating a discrete instrument on an empty background.

Definition 11.338 (Design configuration). A *design configuration* is the current

Table 11.19: Intervention-design dimensions as a context-sensitive analytical repertoire.

Design dimension	Analytical object	Reason for inclusion	Possible form
Practical orientation	Valued direction, protection, obligation, or exploratory purpose	Clarifies what gives the intervention practical direction	Qualitative commitment, target, protected condition, partial order
Intervention object	State, relation, subject history, institution, rule, field, capacity, representation	Identifies where practical transformation is directed	Target map, relational description, institutional locus
Mechanism	Proposed pathway connecting intervention to later change	Makes the generative hypothesis inspectable	Narrative mechanism, causal model, process map, simulation
Timing / scale / depth	Temporal position, practical resolution, transformation depth	Locates the intervention within its operating field	Stage plan, multi-scale map, depth profile
Enabling and constraining conditions	Capacities, authority, resources, protections, dependencies	Identifies conditions affecting viability and admissibility	Institutional analysis, legal constraints, capacity profile
History and possibility effects	Expected, adverse, alternative, and option-space consequences	Extends design beyond one forecasted outcome	Scenario family, historical analysis, option profile
Observation and learning	Monitoring, feedback, epistemic events, evaluation	Connects implementation to later revision	Indicator system, qualitative inquiry, participatory review
Responsibility and contestability	Authority, duties, affected positions, challenge routes	Preserves accountability across distributed action	Responsibility map, review procedure, appeal channel
Revision / exit	Reopening, repair, rollback, termination, residual obligation	Preserves capacity to alter or end the intervention	Trigger conditions, revision rule, exit architecture

version of the intervention architecture, including the subset of design dimensions judged materially relevant, the relations among them, their evidential and normative provenance, and the conditions under which the configuration should be reopened.

The design configuration can be represented through a document, process map, formal model, institutional protocol, participatory agreement, legal instrument, or combination of these. Its adequacy depends on whether the representation supports the decisions being made. A universal diagram would be less informative than a local representation that preserves the field's actual relations.

Design composition can also be iterative. Mechanism analysis can reveal a missing enabling capacity; participatory inquiry can identify an affected position; legal review can change the action set; a pilot can reveal an unanticipated dependency. The configuration should therefore permit addition, removal, or reinterpretation of design dimensions without treating every change as failure of the original method.

11.19.2 Selective Relevance of Design Dimensions

The design repertoire is selective by construction. Target, timing, scale, depth, monitoring, and exit are frequently important, but their required resolution differs. Some interventions have no single target because they seek to create a coordination field or open a deliberative process. Some have no precise endpoint because their purpose is capability formation. Some are principally protective and therefore organize around constraints rather than outcome maximization.

Definition 11.339 (Design-relevance test). A *design-relevance test* asks whether explicit representation of a candidate design dimension would materially change understanding of mechanism, affected positions, authority, consequence, reversibility, learning, or responsibility for the intervention under consideration.

The test creates a practical reason for inclusion. A detailed exit plan can be essential for a temporary infrastructure on which subjects can become dependent and unnecessary for a one-time informational clarification. A formal mechanism model can be useful for a complex feedback intervention and excessive for a simple administrative correction. A participatory design process can be central where affected meanings and consequences are weakly represented by existing institutions.

Selective relevance also protects the meta-framework from procedural inflation. Methodological completeness should not be measured by the number of boxes completed. It should be measured by the fit between the design architecture and the practical relations that can materially affect action and consequence.

11.19.3 Orientation, Intervention Object, and Mechanism

Practical orientation, intervention object, and mechanism form a central but non-universal design relation. The orientation identifies the direction or protection that gives action meaning. The intervention object identifies what part of the field is being acted upon. The mechanism states how the action is expected to contribute to change. Each can remain plural or provisional.

A mechanism can be causal, institutional, relational, informational, legal, technological, symbolic, or mixed. It can act by relaxing a constraint, changing an incentive, generating a capacity, reconfiguring a relation, altering a rule, creating redundancy, redistributing authority, changing a representation, or opening a new action pathway. The intervention architecture should make the mechanism explicit to the degree needed for monitoring and learning.

Definition 11.340 (Mechanism-orientation alignment). *Mechanism-orientation alignment* is the documented relation between a practical orientation and the proposed transformation pathway through which an intervention is expected to contribute to that orientation within the specified field.

Alignment is an object of inquiry, not a guarantee of success. An intervention can realize its immediate mechanism while generating consequences that weaken the broader orientation. A classification can increase administrative coordination while reducing contestability. A capacity intervention can improve performance while creating dependency. Design therefore connects local mechanism to broader history-space effects.

11.19.4 Enabling and Constraining Conditions

Interventions depend on conditions that permit, shape, or limit their operation. These can include authority, resources, institutional competence, infrastructure, trust, legal permission, data access, knowledge, coordination, ecological conditions, technical interoperability, or social acceptance. Some conditions should be created before intervention; others can be generated through the intervention itself.

Constraints also have heterogeneous meanings. A material limit, legal protection, safety condition, budget, right, ecological boundary, institutional rule, and historical obligation can all restrict the available action space while carrying different normative and practical status. Section 11.3 treats these differences within the evaluative frame, and Section 11.12 shows how some can enter formal models. Intervention design should preserve their meanings when they are combined.

Definition 11.341 (Condition architecture). An *intervention condition architecture* records the enabling capacities, dependencies, authority relations, protections, material constraints, and institutional conditions whose presence or absence materially affects whether the intervention can operate as intended.

A condition architecture can reveal that the direct target is secondary to capability formation. An intervention can become viable only after training, institutional recognition, data infrastructure, trust repair, legal authorization, or coordination capacity has been created. In these cases, the design should represent the generative conditions as part of the intervention history.

11.19.5 History-Space and Action-Space Effects

An intervention can change more than the immediate outcome. It can create or close future actions, alter dependencies, reshape expectations, stabilize categories, change institutions, or modify the accessibility of later histories. Design therefore benefits from examining second-order effects on history and possibility spaces where these are materially relevant.

The analysis can use scenario families, historical interpretation, formal transition models, participatory anticipation, or other methods. A design does not need to enumerate every possible future. It should represent the histories capable of changing the practical judgment being made: expected pathways, important adverse pathways, transformative possibilities, and cases in which the assumed mechanism fails.

Definition 11.342 (Possibility-space effect). A *possibility-space effect* is a change in the accessibility, feasibility, authorization, cost, or practical meaning of future actions or histories generated partly through an intervention or its institutional uptake.

Possibility-space analysis is particularly relevant when interventions create infrastructure, categories, dependencies, irreversible investments, institutional precedent, or new capabilities. A favorable immediate result can coexist with long-horizon foreclosure. An initially modest intervention can also generate capacities that make previously unreachable paths accessible.

11.19.6 Observation, Revision, and Exit as Embedded Dimensions

Monitoring, revision, and exit can be designed from the beginning when their later feasibility depends on capacities or records that must be preserved during implementation. A rollback option can require technical modularity. Later evaluation can require a pre-intervention record. Contestable revision can require a governance body. Exit from a temporary service can require replacement capacity.

This does not imply that every intervention needs a detailed monitoring protocol before action. Emergency or exploratory action can begin with limited information. The design question is whether the absence of an observation, revision, or exit arrangement materially reduces the ability to detect harm, learn, repair, or preserve responsibility at the current level of commitment.

Definition 11.343 (Embedded revisability). *Embedded revisability* is the extent to which an intervention preserves the practical, epistemic, institutional, and material conditions needed to reconsider, alter, repair, narrow, terminate, or transfer the intervention as later history unfolds.

Sections 11.21–11.25 develop monitoring, feedback, evaluation, repair, exit, and rollback in detail. The present section establishes only their design-level status: they are possible components of intervention composition when later adaptation depends on them.

11.19.7 Provenance, Responsibility, and Contestability

Intervention design distributes practical authority. Different actors can diagnose, model, authorize, implement, monitor, evaluate, fund, contest, or experience the intervention. A design becomes difficult to govern when these roles are distributed without a visible responsibility architecture.

Definition 11.344 (Design-responsibility map). A *design-responsibility map* records the materially relevant roles of authorization, implementation, epistemic judgment, monitoring, review, repair, communication, and consequence management together with the relations through which those responsibilities can be exercised and contested.

Responsibility can remain shared without becoming vacant. A model can inform a recommendation while an institution retains authorization responsibility. A contractor can implement part of an intervention while the commissioning body retains duties concerning monitoring or remedy. A participatory body can shape design without carrying liabilities that exceed its authority. Making these relations explicit supports later analysis of distributed and machine-mediated decision support.

Contestability also belongs to design where representations or decisions can materially affect subjects. Challenge can concern factual error, category mismatch, model assumption, procedural exclusion, legal standing, or normative disagreement. Different challenge types require different institutions. A technically auditable model does not by itself provide a meaningful route for contesting the values embedded in its use.

11.19.8 Proportionate Design Depth

The depth of design should reflect the depth of practical commitment. A bounded and reversible action can be governed through a compact record. A deep, long-duration, difficult-to-reverse intervention can justify more extensive historical reconstruction, model comparison, participation, independent review, monitoring, repair planning, and residual-obligation analysis.

Definition 11.345 (Proportionate design depth). *Proportionate design depth* is the degree of explicit analysis, documentation, review, and revisability devoted to an intervention in relation to its scale, duration, uncertainty, distributive concentration, dependency generation, institutional depth, and reversibility.

Proportionality prevents the meta-framework from becoming administratively maximalist. Additional procedure can itself impose cost, delay urgent action, concentrate expertise, or exclude actors unable to participate in complex documentation. The design architecture should therefore justify both what it includes and what it deliberately leaves implicit.

Proposition 11.346 (Meta-level intervention-design adequacy). *A situated intervention design is methodologically adequate to the extent that the design dimensions materially relevant to its field are represented with sufficient provenance, relational context, responsibility, protection, and revisability for the commitment being made, while dimensions with little practical relevance remain available without becoming mandatory procedural requirements.*

Proposition 11.346 makes the status of Section 11.19 explicit. The section provides a repertoire and a composition logic. It does not define a universal intervention template. Section 11.20 develops experimental and pilot intervention as one possible mode of practical learning within this broader architecture.

11.20 Experimental and Pilot Intervention

Section 11.19 treated intervention design as a situated composition drawn from a context-sensitive repertoire of orientations, intervention objects, mechanisms, temporal and scalar dimensions, enabling conditions, history-space effects, observation arrangements, responsibility relations, revision pathways, and exit conditions. The present section develops the next methodological step: bounded practical contact with the field through pilots and experimental arrangements. Its role is to specify how an intervention can be introduced under controlled or deliberately limited conditions so that feasibility, mechanism, implementation, observation, consequence, and revision capacity can be learned without treating experimentation as epistemically neutral or ethically costless. Its objective is to distinguish several forms of practical experimentation, explain how intervention-generated evidence should be interpreted, preserve the distinction between observation and performative transformation, develop reversibility and protection conditions, and clarify what can and cannot be inferred when moving from a bounded experiment toward wider implementation. The discussion proceeds through pilot design, field, natural, policy, and institutional experiments, intervention-generated evidence, performative observation, reversible experimentation, ethical limits, and scaling after experiment.

Definition 11.347 (Experimental intervention). An *experimental intervention* is a deliberately structured practical transformation, or a structured comparison around a transformation, whose design preserves explicit questions about feasibility, mechanism, implementation, consequence, or transfer and whose observation architecture is organized so that the resulting practical history can revise later judgment and action.

Experimental intervention is broader than a laboratory-style manipulation. It can include field trials, policy pilots, staged institutional reforms, naturally occurring contrasts, or other bounded practical arrangements in which observed variation can inform later praxis. The category is functional rather than disciplinary: what matters is the relation among intervention, comparison, observation, practical consequence, and revision.

The boundedness of an experiment should not be confused with absence of consequence. A pilot can change expectations, create temporary rights or dependencies, generate new categories, mobilize resources, establish institutional precedents, alter trust, or open and foreclose later action paths. It can also change the subjects and institutions that participate in the experiment. Experimental design should therefore inherit the responsibility, justice, participation, and closure requirements developed in Chapter 10 rather than operate under a presumption of harmlessness.

Definition 11.348 (Experimental intervention dossier). An *experimental intervention dossier* is the versioned record of the experimental objective, practical and epistemic questions, target, intervention mechanism, event-order architecture, comparison structure, affected positions, exposure, observation regime, expected and alternative histories, reversibility provisions, ethical protections, decision gates, revision rules, exit conditions, and conditions for transfer or wider implementation.

Table 11.20 summarizes the methodological architecture. The dimensions should not be interpreted as a linear checklist. A pilot can contain policy and institutional experimentation; field observation can be performative; ethical constraints can determine experimental scale and depth; and the possibility of later scaling should shape which mechanisms and enabling conditions are observed from the beginning.

11.20.1 Pilot Design

A pilot is a bounded intervention used to learn about practical feasibility, mechanism, implementation, affected positions, institutional response, observation, and revision before deeper or wider commitment. Its value lies in creating a deliberately limited practical history whose consequences can inform later action. A pilot should therefore be designed as an intervention in its own right rather than as an administratively smaller copy of an eventual programme.

Definition 11.349 (Pilot intervention). A *pilot intervention* is a bounded, monitored, and revisable practical intervention whose scale, duration, depth, exposure, institutional commitment, or action-space effect is intentionally limited so that selected practical and epistemic questions can be examined before a later commitment is made.

Pilot boundedness can concern several dimensions. A pilot can be limited geographically, institutionally, relationally, temporally, by participant exposure, by in-

Table 11.20: Methodological dimensions of experimental and pilot intervention.

Dimension	Primary methodological object	Characteristic question
Pilot design	Bounded practical commitment	What can be learned while limiting exposure, lock-in, and irreversible consequence?
Field experiment	Designed variation in an operating field	Which practical differences can be attributed under real implementation conditions?
Natural experiment	Historically generated comparison	Which contrast is informative without treating naturally occurring variation as automatically exogenous?
Policy experiment	Rule, programme, or public-action variation	How do implementation, response, distribution, and legitimacy alter the experimental history?
Institutional experiment	Roles, mandates, routines, or governance arrangements	How does the institution adapt, reinterpret, and reproduce the experimental design?
Intervention-generated evidence	Evidence produced through practical transformation	What was revealed, created, activated, or obscured by the intervention itself?
Performative observation	Observation that can alter the field	How do measurement, classification, disclosure, and attention change later histories?
Reversible experimentation	Rollback and repair capacity	Which commitments can be reversed, and which residues remain after reversal?
Ethical limits	Exposure, burden, standing, and protection	Which experimental commitments remain admissible under uncertainty and unequal power?
Scaling	Transfer into a changed scale and field	Which mechanism, capability, protections, and history structure survive or transform beyond the experiment?

tervention depth, by authority, or by the range of histories it is permitted to generate. These dimensions need not coincide. A geographically small pilot can still be institutionally deep if it changes legal standing, durable classification, or organizational rules. Conversely, a wide informational intervention can remain shallow if it leaves authority and institutional relations unchanged.

The pilot should begin with explicit questions. These can concern whether an enabling condition exists, whether a proposed relation can be sustained, whether an observation regime is usable, whether an institution can implement the design, whether affected subjects experience an omitted burden, whether a mechanism appears to

operate, or whether rollback remains feasible after real contact with the field. An experiment that produces abundant data without a defined practical question can still generate information, but its relation to later commitment becomes difficult to reconstruct.

Definition 11.350 (Pilot envelope). A *pilot envelope* specifies the permitted scale, duration, depth, affected positions, exposure, event-order boundaries, resource commitment, authority, observation regime, reversibility reserve, and conditions under which the pilot may continue, expand, pause, narrow, or terminate.

The pilot envelope should include event-order conditions. Under the temporal architecture of Section 11.16, some enabling or protective events may need to precede intervention events. Training can need to precede delegated authority; consent or institutional authorization can need to precede data collection; fallback capacity can need to exist before a reversible technical intervention begins. Other events can remain unordered where no relevant precedence is asserted. Clock time can be added where operational synchronization is necessary, but it need not define the underlying historical structure.

A pilot also needs a pre-specified relation to later decision. Successful implementation does not automatically imply scale-up. A pilot can support continuation, modification, additional inquiry, bounded extension, or termination. The decision gate after a pilot should therefore refer to mechanism evidence, implementation capacity, adverse and distributional consequences, reversibility, residual uncertainty, and whether the pilot itself changed the field in ways that make the original comparison obsolete.

Finally, pilot design should preserve a counterfactual memory. Once participants, institutions, and observers experience the pilot, the pre-pilot field may no longer be recoverable. The dossier should record the earlier action space, institutional configuration, observation regime, and affected positions sufficiently well that later evaluation can distinguish changes created by the pilot from conditions that preceded it.

11.20.2 Field Experiment

A field experiment introduces designed variation within an operating practical environment. Its methodological attraction is that the intervention occurs under conditions closer to those in which later action may actually operate. Its methodological difficulty is that real fields contain strategic response, institutional adaptation, interference among units, heterogeneous implementation, and performative observation. The design should therefore preserve these relations rather than treat them only as deviations from ideal experimental control.

Definition 11.351 (Field experimental configuration). A *field experimental configuration* is a practical arrangement in which selected intervention conditions or assignments are deliberately varied within an operating field and linked to an observation and comparison architecture designed to support bounded causal, mechanistic, implementation, or consequence-related inference.

Assignment or intervention contrast can strengthen causal interpretation under

appropriate conditions, but the relevant inferential object should remain explicit. A field experiment can estimate a local treatment contrast without establishing the deeper generative mechanism, transferability, institutional sustainability, or long-horizon effect. Conversely, a heterogeneous response that weakens a simple average effect can reveal a relational or institutional structure that is practically more important than the aggregate estimate.

Interference deserves particular attention in GR. If one participant's exposure changes another participant's behavior, if information spreads through a network, or if institutional staff reorganize around the intervention, the field does not decompose into independent units. Such interference can be modeled where appropriate through networks, fields, higher-order relations, or clustered structures. It can also be treated qualitatively when the formal assumptions required for a quantitative model are unsupported.

Field experiments can generate epistemic events outside the intended intervention. Participants can infer the purpose of the experiment; staff can change behavior because they know they are observed; public communication can alter expectations; classification into treatment or comparison categories can acquire social meaning. The experimental field is therefore historically transformed by the experiment's existence. The design should record these transformations and interpret the resulting estimates within that changed field.

The practical consequence of a field experiment also extends beyond estimation. The intervention may generate skills, trust, resentment, routines, infrastructure, expectations, or claims to continuation. A later decision to stop or scale the experiment should account for these generated conditions. Experimental closure is thus a practical event with residual consequences, not merely the end of data collection.

11.20.3 Natural Experiment

A natural experiment differs from a designed field experiment because the investigator does not create the relevant variation solely for experimental identification. A historical, administrative, environmental, institutional, or other process generates a contrast that can potentially support causal or comparative inference. The methodological opportunity arises from the structure of the event history; the principal danger is treating a convenient contrast as though its assignment mechanism were automatically exogenous or random.

Definition 11.352 (Natural-experimental contrast). A *natural-experimental contrast* is an historically generated difference in exposure, timing, eligibility, assignment, or institutional condition whose generative pathway can be reconstructed sufficiently to support a bounded comparison without representing the investigator as the source of the variation.

The first task is therefore historical reconstruction. The event that creates the contrast should be situated within its predecessor relations, institutional process, affected positions, and possible anticipatory responses. If actors could influence assignment, move across the boundary, adapt before exposure, or receive correlated interventions, the contrast can embody selection and relational response that undermine a simple causal interpretation.

Natural experiments can be especially useful in an event-ordered representation. Rather than beginning from a calendar discontinuity alone, the analysis can ask which events precede exposure, which events become incomparable across branches, and which later outcomes depend on the institutional path that generated the contrast. A date or threshold can be operationally useful while remaining only one label on the deeper event history.

A natural-experimental comparison should also distinguish identification from transport. A historically specific event can produce a credible local contrast while remaining difficult to generalize to another institution, scale, or historical field. The mechanism that created the variation can itself be unique. Transfer therefore requires the same historical, relational, and institutional scrutiny developed in Sections 11.13 and 11.17.

Because the investigator did not create the initiating event, the ethical architecture differs from deliberate experimentation but does not disappear. Data use, interpretation, privacy, representation, communication, and downstream decisions can still generate burdens and performative effects. Natural occurrence does not make later research or policy use normatively neutral.

11.20.4 Policy Experiment

Policy experimentation applies bounded variation, staged implementation, or deliberately revisable design to rules, programmes, resource arrangements, or other forms of organized public or collective action. Its distinctive methodological feature is that the intervention can alter incentives, authority, rights, expectations, institutional routines, and strategic response while simultaneously being evaluated. The policy object therefore often changes the field more deeply than a narrow technical treatment.

Definition 11.353 (Policy experimental architecture). *A policy experimental architecture* is a bounded and revisable arrangement in which a policy rule, programme, eligibility structure, resource arrangement, or implementation pathway is introduced or varied so that practical consequences, mechanisms, implementation conditions, and revision needs can be learned under explicit governance and protection conditions.

Policy experiments should distinguish variation in formal design from variation in implementation. The same formal rule can produce different practical histories when administrative capacity, local interpretation, communication, enforcement, trust, or complementary services differ. The experimental object should therefore include both the policy specification and its enacted institutional configuration.

Policy experimentation also creates expectations. Temporary eligibility can be experienced as recognition; a pilot service can create reliance; an announced trial can change investment or migration decisions; a temporary rule can become a focal point for institutional bargaining. These consequences can persist after the formal experiment ends. The exit architecture should therefore identify which generated expectations or dependencies require transition, explanation, compensation, replacement, or continued support.

Distributional comparison is also central. Average benefit can coexist with concen-

trated burden, unequal access, or differential implementation. Experimental design should preserve affected positions and value plurality rather than rely only on an aggregate outcome. Participatory and interpretive methods can be necessary to identify effects that a narrow quantitative indicator misses.

A policy experiment can also modify the action space of later decision-makers. It can create administrative capacity, establish a legal category, produce interoperable infrastructure, or demonstrate an alternative that did not previously appear reachable. These generative effects belong to the experimental result even where they were not the primary outcome measure.

11.20.5 Institutional Experiment

Institutional experimentation changes roles, mandates, routines, decision rights, accountability pathways, representation, memory, coordination, or other durable organizational arrangements under bounded and revisable conditions. It is often deeper than a programme pilot because the object of experimentation is part of the architecture through which later interventions are authorized, interpreted, and maintained.

Definition 11.354 (Institutional experiment). An *institutional experiment* is a bounded and governed modification of roles, mandates, routines, authority, accountability, representation, coordination, memory, or other institutional arrangements undertaken so that the practical and generative consequences of the modified institutional configuration can be observed and revised.

The unit of analysis can therefore be an institutional relation rather than an individual subject. Examples include changing who can authorize a decision, adding a review interface, creating a cross-unit coordination role, altering information handoff, or introducing a protected dissent pathway. The relevant outcomes can include response time, error detection, trust, learning, burden distribution, institutional memory, or the generation of new practical options.

Institutional experiments are path-sensitive. Once roles are created, staff trained, records reorganized, or authority redistributed, the pre-experimental institution may no longer be recoverable at low cost. Formal reversibility can therefore overstate practical reversibility. The experiment should preserve a reversibility reserve where possible and record institutional residues that would remain after rollback.

Institutional actors also learn the experimental rule. They can adapt around it, create informal workarounds, strategically route cases, or reinterpret mandates. Such adaptation is not necessarily experimental contamination; it can be part of the generative mechanism. The design should distinguish adaptation that reveals an institutional capability from adaptation that defeats the intended protection or makes the original experiment difficult to interpret.

Because institutional experimentation can alter authority and standing, participation and accountability are especially important. Those affected by a new institutional arrangement can possess knowledge unavailable to the designers and may bear transition costs without holding formal decision rights. The experimental dossier should therefore preserve who was represented, who could contest the design, and who acquired or lost practical power during the experiment.

11.20.6 Intervention-Generated Evidence

Experimental praxis produces evidence from a field that has been changed by the intervention. This fact is epistemically productive but requires discipline. Evidence generated after intervention can reveal how the transformed field behaves; it does not automatically describe the pre-intervention field, an untreated future, or another context. The evidential object should therefore include the intervention history through which the observation became possible.

Definition 11.355 (Intervention-generated evidence). *Intervention-generated evidence* is evidence whose availability, content, distribution, or interpretive significance depends materially on a practical intervention or on the relational, institutional, epistemic, or historical changes produced by that intervention.

Four distinctions are especially useful. An intervention can *reveal* a previously existing relation by making it observable. It can *activate* a latent capacity or mechanism. It can *create* a new relation, category, institution, or capability. It can also *obscure* an earlier condition by changing the observation environment. These processes can coexist, and the resulting evidence should not be assigned to one category without justification.

The evidential provenance should therefore include the intervention version, event order, affected positions, observation regime, implementation adaptations, and relevant field changes. A later analyst should be able to ask whether an observation resulted from the intended mechanism, from the act of observation, from institutional adaptation, from a newly generated capability, or from another contemporaneous transformation.

Experimental evidence can also revise the model family itself. A pilot can reveal that a presumed variable is better represented as a relation, that a fixed subject should be modeled historically, that a transition assumed to be smooth is threshold-dependent, or that a history-space branch omitted at design time is practically important. Such evidence should permit structural model revision rather than be forced into parameter updating of the original model.

Proposition 11.356 (Experimental evidence provenance). *Evidence generated through experimental intervention supports later practical inference only to the extent that the intervention history, observation regime, affected field, inferential target, and relevant changes in representation or mechanism remain sufficiently explicit for the evidential relation to be reconstructed and contested.*

Proposition 11.356 does not require complete reconstruction of the field. It requires enough provenance to prevent evidence from being detached from the intervention conditions that helped produce it.

11.20.7 Performative Observation

Observation inside an experiment can become part of the intervention. Section 11.4 distinguished readout from state transformation while allowing an epistemic event to become performatively coupled to later evolution. Experimental settings make this coupling especially important because measurement, classification, feedback, disclosure, and attention are often built directly into the intervention protocol.

Definition 11.357 (Performative experimental observation). A *performative experimental observation* is an observation, classification, measurement, disclosure, or interpretive event whose production or uptake materially alters the practical configuration, later behavior, institutional process, or accessibility of subsequent histories within the experimental field.

The typed distinction can be preserved schematically. Let an observation map produce a representation,

$$\pi^{(c)} : \Omega \longrightarrow X^{(c)}. \quad (11.46)$$

Equation 11.46 is a readout. If the resulting representation is recognized and institutionally coupled to a transformation, the later state change is represented separately through

$$\Phi_e : \Omega \rightharpoonup \Omega. \quad (11.47)$$

Equation 11.47 represents transformation, not observation itself. The distinction allows an experiment to ask both what was observed and what changed because the observation became actionable.

Performative effects can arise through several pathways. Public measurement can redirect attention. Classification can change eligibility or identity. Feedback can alter behavior. Monitoring can generate strategic reporting. Disclosure can change expectations. Repeated observation can burden participants and change participation. These effects can be undesirable, beneficial, or constitutive of the intervention mechanism itself.

A performativity record should therefore specify the observation event, representation produced, uptake pathway, transformation generated, affected positions, and whether the resulting field remains comparable with earlier observations. Where observation materially changes the experimental system, later measurements should not be interpreted as repeated samples from an unchanged process without further argument.

11.20.8 Reversible Experimentation

Reversibility can make experimentation more informative and ethically defensible, but experimental reversibility should be treated as a practical architecture rather than a label. An intervention can be technically reversible while leaving institutional, relational, epistemic, or historical residues that cannot be undone. The design should therefore distinguish rollback of the focal intervention from restoration of the earlier field.

Definition 11.358 (Reversible experimental architecture). A *reversible experimental architecture* is an experimental design that preserves specified authority, capability, resources, interfaces, records, alternatives, repair pathways, and transition arrangements so that the focal intervention can be reduced, suspended, withdrawn, replaced, or rolled back under defined conditions while residual consequences remain explicitly tracked.

Reversible experimentation requires a *reversibility reserve*. This can include fallback infrastructure, financial or material reserves, maintained expertise, preserved access routes, authority to suspend implementation, parallel systems, data needed for restoration, or institutional memory. The reserve should remain available throughout the experiment rather than be consumed by early implementation.

Rollback should also have event-order prerequisites. Replacement capacity can need to exist before withdrawal. Participants can require transition notice before a service ends. Records can need transfer before an institution is dissolved. If those predecessor events are absent, formal authority to stop does not amount to practical reversibility.

The experiment should identify *irreversible residues*. These can include disclosure of private information, changed expectations, learned behavior, environmental transformation, altered institutional legitimacy, path-dependent investments, or created categories. A reversible experiment can therefore remain justified while acknowledging that full restoration is impossible. The relevant question is whether the remaining residues are understood, acceptable, repairable where necessary, and proportionate to the learning and practical objective.

Reversible experimentation also has epistemic value. It permits stronger practical contact while preserving a pathway for correction when model assumptions fail. Yet this benefit should not encourage unnecessary experimentation on affected subjects. Reversibility reduces some risks; it does not erase burdens, power asymmetries, or duties of justification.

11.20.9 Ethical Limits

Experimental methodology is constrained by the fact that the objects of application-dominant praxis can be subjects and institutions whose welfare, rights, standing, relations, and future options are affected by the experiment. Methodological informativeness does not by itself justify exposure. Ethical limits should therefore be built into experimental design as constitutive constraints rather than appended after the experiment has been optimized for learning.

Definition 11.359 (Experimental protection architecture). An *experimental protection architecture* is the set of substantive, procedural, relational, and institutional conditions that bound experimental exposure, preserve protected interests and standing, allocate responsibility, enable contestation and remedy, and constrain learning objectives when experimentation can impose burdens or alter future possibilities.

Several dimensions require explicit attention. *Exposure* concerns who can experience harm, burden, deprivation, uncertainty, stigma, surveillance, or opportunity loss. *Standing* concerns whose interests and interpretations count in experimental design. *Authority* concerns who is permitted to impose variation. *Participation* concerns whether affected subjects can shape or contest the experimental architecture. *Distribution* concerns whether learning benefits accrue to one position while experimental burdens fall on another. *Remedy* concerns repair, compensation, review, and reopening when harm occurs.

The ethics of comparison groups also require context-sensitive judgment. With-

holding an intervention can be methodologically informative in some cases while becoming unacceptable when established protection, rights, or urgent needs would be denied. Conversely, universal immediate rollout can make learning difficult and create larger irreversible exposure when the intervention remains uncertain. The appropriate design depends on the existing epistemic state, consequence severity, reversibility, available alternatives, legitimate authority, and distribution of burden. No single comparison architecture is ethically privileged in advance.

Experimental subjects should not be reduced to data-generating units. Participation can change the experiment itself, and participants may possess knowledge required to understand burden, mechanism, or feasibility. Protection should therefore include intelligibility, voice, contestability, privacy where relevant, safe withdrawal where feasible, and clear allocation of responsibility for consequences. Where individual consent is impossible or insufficient for an institutional experiment, other forms of legitimate authorization and protection remain necessary rather than disappearing.

The experiment should also consider future agency. A bounded trial can create lock-in, normalize surveillance, deplete institutional alternatives, or establish categories difficult to reverse. Ethical evaluation should therefore include history-space and action-space effects, not only immediate outcome risk. A pilot that appears low-risk in the present can still be ethically significant if it materially narrows the choices of later actors.

Proposition 11.360 (Experimental proportionality). *Experimental exposure is methodologically and ethically supportable only when the practical and epistemic value of the experiment, the seriousness of the problem, residual uncertainty, reversibility, burden distribution, affected positions, available alternatives, protection architecture, and expected future-option effects jointly support the depth and scale of commitment.*

Proposition 11.360 is intentionally plural rather than scalar. The relevant considerations need not be collapsed into a single benefit–risk score.

11.20.10 Scaling after Experiment

Scaling after an experiment is a new intervention-design problem rather than mechanical replication of a successful pilot. Increasing breadth, duration, institutional depth, authority, or integration can change the mechanism, affected positions, implementation burden, field structure, observation regime, and history space. A pilot result therefore supplies evidence for scaling only through an explicit transfer and transformation argument.

Definition 11.361 (Scale-transition inference). A *scale-transition inference* is a reasoned and revisable inference connecting evidence and mechanism from an experimental configuration to a proposed wider, deeper, longer, or more institutionalized intervention while explicitly representing the conditions expected to remain stable, the conditions expected to change, and the uncertainties generated by the transition itself.

Scaling can occur along several dimensions. *Breadth scaling* increases the num-

ber or range of affected positions. *intensity scaling* increases intervention magnitude or resource commitment. *temporal scaling* lengthens duration. *institutional scaling* embeds the intervention into durable roles or rules. *depth scaling* reaches further into generative structure. *network scaling* propagates through additional relational pathways. These dimensions can produce different histories even when the nominal programme name remains unchanged.

The scaling question should therefore revisit mechanism validity. A mechanism observed in a small pilot may depend on unusually skilled staff, concentrated attention, temporary resources, participant selection, novelty, or a dense coordination relation that will not exist at wider scale. Scaling can also create interference, congestion, strategic adaptation, supply constraints, or institutional standardization absent in the pilot. The experimental mechanism should be decomposed into components expected to survive the scale transition and components requiring new support.

Scale transition can be examined through the coarse-graining and scale-translation architecture of Section 11.17. If a transformation represented at pilot resolution does not have an adequate counterpart at the proposed wider scale, the intervention may require redesign rather than replication. Likewise, the event-order architecture can change: capabilities generated early in the pilot may need to be generated anew in each scaling branch, and institutional authorization can become a predecessor event that did not exist in the smaller trial.

Definition 11.362 (Scaling remainder). A *scaling remainder* is a practically material mechanism, relation, burden, capability, historical condition, epistemic effect, or uncertainty present in the experimental configuration that lacks a justified correspondence in the proposed scaled configuration, or vice versa.

The scaling remainder should remain visible. It can justify staged expansion, additional pilot branches, redesigned monitoring, stronger participation, or refusal to generalize a result beyond its validity region. A successful experiment can therefore rationally support continued local use without supporting universal expansion.

Scaling should also preserve learning. A wider intervention can remain staged, versioned, and reversible rather than becoming a one-time irreversible rollout. The next implementation stage can generate new epistemic events, reveal new affected positions, change history weights, or generate new action spaces. Scaling architecture should consequently include new monitoring, decision gates, revision conditions, and exit pathways appropriate to the transformed field.

Proposition 11.363 (Experimental transfer and scaling). *Evidence from a pilot or experiment supports wider intervention only to the extent that the relevant mechanism, enabling conditions, affected positions, institutional capacities, observation effects, event-order relations, protections, and history-space consequences possess a defensible correspondence to the proposed scaled configuration, with material remainders and new uncertainties preserved explicitly.*

Proposition 11.363 closes the experimental-intervention block by treating experiment as a generator of practical evidence and transformed conditions rather than as a simple prelude to rollout. Once an intervention enters practice, the next methodological task is to observe its evolving histories continuously enough to detect mechanism change, burden distribution, emerging risks, generative effects, and the conse-

quences of observation itself. Section 303 therefore turns to monitoring and observation regimes.

11.21 Monitoring and Observation Regimes

Section 11.20 developed experimental and pilot intervention as bounded practical contact with an evolving field. The present section develops the observation architecture required once intervention, institutional response, and practical learning continue through time. Its role is to specify how application-dominant praxis can remain epistemically connected to the histories it helps generate without treating observation as passive, indicators as self-interpreting, or monitoring as costless. Its objective is to distinguish immediate, relational, generative, early-warning, and distributional indicators; preserve the typed distinction between readout and transformation; trace action-generated and unintended evidence; support revision of data and representation; and make the burdens of observation themselves visible. The discussion proceeds through observation architecture, several classes of indicators, observer and classification effects, action-generated evidence, unintended effects, data and representation updating, and monitoring burden.

Definition 11.364 (Monitoring regime). A *monitoring regime* is a versioned practical arrangement that specifies what is observed, by whom, through which representation and instrumentation, under which event-order or clock-time conditions, with what provenance and uncertainty, how observations are interpreted and communicated, how observation may affect the field, and which forms of review, revision, escalation, de-escalation, or reopening the resulting epistemic events can activate.

Monitoring is therefore broader than repeated measurement. A monitoring regime can contain quantitative indicators, qualitative observation, participant testimony, institutional records, field inspection, relational mapping, model-generated diagnostics, and event-triggered review. The regime should preserve the distinction between the practical configuration, the observations produced from it, and the transformations that can follow when those observations are interpreted or institutionally taken up.

Table 11.21 summarizes the architecture. The dimensions are mutually connected. An indicator can become performative; an unintended effect can require a new indicator; a distributional pattern can reveal an omitted relation; and monitoring burden can itself alter participation, trust, reporting behavior, or implementation capacity. Monitoring adequacy therefore depends on the regime as a whole rather than on the number of variables collected.

11.21.1 Observation Architecture

An observation architecture specifies the typed relation among practical configuration, observation event, representation, interpretation, institutional uptake, and possible later transformation. Its methodological purpose is to prevent the observation record from being treated as if it were identical to the field and to make explicit where performative effects can enter the practical history.

Table 11.21: Methodological dimensions of monitoring and observation regimes.

Dimension	Primary observation object	Characteristic methodological question
Observation architecture	Observer, object, representation, provenance, and trigger structure	Which observations are produced, under which conditions, and how can they enter later praxis?
Immediate indicators	Manifested state and near-term response	Which changes are visible now, and which conclusions remain premature?
Relational indicators	Dependency, authority, trust, flow, coordination, and access	How are consequential relations changing across positions and interfaces?
Generative indicators	Capacity, option structure, rule change, and future-history potential	Which conditions governing later generation are being strengthened, depleted, or transformed?
Early-warning indicators	Precursors, event patterns, thresholds, and structural changes	Which observations justify attention before major consequences fully manifest?
Distributional indicators	Benefits, burdens, exposure, voice, and recovery capacity	How are consequences distributed across affected positions and horizons?
Observer and classification effects	Performative consequences of observation and representation	How does observing, classifying, disclosing, or ranking change the field being observed?
Action-generated evidence	Evidence produced through intervention histories	What was revealed, activated, created, or obscured by action itself?
Unintended effects	Spillovers, emergent subjects, and unplanned histories	Which consequential changes fall outside the original target and expectation structure?
Representation updating	Data schema, categories, models, and provenance	When should the observation system itself be revised, and how can comparability be preserved?
Monitoring burden	Cost, exposure, attention, surveillance, and participation load	Which burdens are generated by observation, for whom, and with what justification?

Let Ω denote a model-specific configuration space and $X^{(c)}$ an observation space for channel c . A readout at an observation event e_o can be represented by Equation 11.48.

$$\pi_{e_o}^{(c)} : \Omega \longrightarrow X^{(c)}. \quad (11.48)$$

Equation 11.48 is a representation of readout, not of the later transformation that can occur when the result is interpreted, disclosed, classified, or acted upon. Where

uptake of the observation generates a practical change, a separate transformation can be represented by Equation 11.49.

$$\Phi_{e_u} : \Omega \rightarrow \Omega, \quad (11.49)$$

where e_u is an uptake event whose occurrence can depend on the observation, its interpretation, and the institutional pathway through which it acquires practical force. The two mappings preserve the distinction between knowing something about a configuration and changing the configuration through the practical consequences of knowing, communicating, or institutionalizing it.

Monitoring time should inherit the event-ordered architecture developed in Section 11.16. A general observation regime can be represented by a partially ordered set of monitoring events rather than by a uniform clock-time sequence. Some observations are periodic, but others become meaningful only after particular predecessor events. A review can be triggered after implementation, after a specified number of relevant transactions, after an institutional handoff, after a warning event, or after an affected position becomes newly visible. Two observations can remain unordered where no practical precedence relation is warranted.

Definition 11.365 (Observation architecture). An *observation architecture* specifies observation objects, channels, observers, instrumentation or interpretive procedures, event-order or clock-time triggers, representation spaces, provenance, uncertainty, access, communication pathways, performative coupling, and the practical responses that observation can activate.

The architecture should also preserve observation absences. Missingness can arise because an event did not occur, because it could not be observed, because the observer lacked access, because the category did not exist, because reporting incentives suppressed disclosure, or because the monitoring regime did not yet know what to look for. These absences have different epistemic meanings and should not be compressed into a single missing-data category.

Observation architecture should therefore be designed together with intervention architecture. The relevant question is not only whether a variable can be measured, but whether the regime can detect the histories, relations, burdens, capability changes, and rule transformations that matter for later revision. Monitoring that is easy to automate can still be practically inadequate if it systematically observes only the most legible layer of the field.

11.21.2 Immediate Indicators

Immediate indicators record manifested conditions close to an observation event or intervention stage. They can concern current state, uptake, service continuity, operational performance, safety events, near-term exposure, resource use, or another consequence that becomes observable with relatively little historical delay. Their methodological role is often stabilization and rapid feedback rather than explanation of deeper mechanism.

Definition 11.366 (Immediate indicator). An *immediate indicator* is an observation object designed to represent a present or near-term manifested condition whose prac-

tical relevance can be assessed with limited temporal or generative reconstruction.

Immediate indicators are especially useful when a practical history contains urgent protection requirements or when a staged intervention needs rapid information before proceeding to a deeper commitment. Their interpretive limitation is equally important: short-latency visibility does not establish causal or generative sufficiency. An intervention can improve an immediate output while degrading a slower institutional capacity, relational condition, or future action space. Conversely, a temporary deterioration can accompany beneficial reorganization where transition costs occur before later generative gains become observable.

Immediate monitoring should therefore record the relation between the indicator and the intervention stage. A sudden change before the relevant intervention event should not be attributed to that intervention merely because it appears inside the same reporting period. Event-order provenance can be more informative than coarse calendar aggregation when several transformations occur inside one interval.

A useful immediate-indicator record includes the observation event, represented object, expected latency, uncertainty, comparison basis, affected positions, and the practical response that the indicator can legitimately trigger. This protects immediate indicators from acquiring decision authority beyond their evidential scope.

11.21.3 Relational Indicators

Relational indicators observe changing relations rather than only attributes of isolated positions. Their objects can include dependence, authority, trust, information flow, coordination, recognition, care, exchange, access, exit, exposure, or other relations whose configuration shapes later practical possibility.

Definition 11.367 (Relational indicator). A *relational indicator* is an observation object whose primary referent is a relation, interface, or relational configuration among positions rather than an attribute assigned independently to one position.

A relational indicator can be quantitative, qualitative, structural, or mixed. Network measures can represent some forms of centrality, connectivity, or dependence. Process records can reveal authority or coordination. Interviews and local knowledge can reveal informal relations absent from administrative data. The method should therefore select a representation appropriate to the relation rather than assume that every relation has a natural scalar measure.

Relational indicators require semantic discipline. An observed exchange does not automatically establish trust; frequent communication does not establish influence; formal authority does not establish effective control; and identical edge labels in two contexts do not establish equivalent relational meaning. Where a numerical proxy is used, the proxy-to-relation correspondence should remain explicit and revisable.

The direction and asymmetry of relations also matter. A relation that increases one position's access can increase another position's dependency or monitoring exposure. Relational monitoring should therefore preserve position-specific consequences where they are practically material.

Definition 11.368 (Relational monitoring profile). A *relational monitoring profile* records the represented relation, participating positions, direction or reciprocity

where relevant, observation method, proxy assumptions, historical context, affected interfaces, uncertainty, and the practical consequences of a materially detected change.

Relational indicators can also become early evidence of deeper structural change. Repeated changes in local coordination, exit dependence, or information flow can indicate that an institutional or field-level configuration is being reorganized before aggregate outcomes visibly change.

11.21.4 Generative Indicators

Generative indicators are designed to observe changes in the conditions that shape later production of actions, capacities, relations, institutions, and histories. Their methodological object is therefore broader than current output. They ask whether praxis is altering what subjects and institutions will later be able to generate, sustain, revise, or recover from.

Definition 11.369 (Generative indicator). A *generative indicator* is an observation object intended to represent a condition that materially affects the later generation, preservation, transformation, or foreclosure of capabilities, relations, institutions, action possibilities, epistemic access, or admissible histories.

Examples can include maintenance capacity, institutional memory, training and skill regeneration, trust repair, redundancy, preserved exit capacity, option generation, observation quality, responsiveness to dissent, or the creation of new coordination pathways. The exact object depends on the generative claim being monitored. A generative indicator should therefore be connected to an explicit mechanism or relational hypothesis rather than selected merely because it appears future-oriented.

Generative monitoring should distinguish present state from future potential. A reserve can remain unused while materially increasing recoverability. A new institutional interface can have little immediate throughput while increasing future coordination capacity. Conversely, a system can maintain present output while consuming the capacities that make later output possible. Monitoring architecture should make these slow or latent conditions visible where they matter.

Where a model uses evolving action spaces, monitoring can examine whether new actions become reachable, latent actions lose activation pathways, or existing options become increasingly costly or dependent on one controlling position. Where a model uses history weights or transition potentials, a monitoring event can justify revision of the relative support assigned to future histories. These are model-specific representations rather than universal quantities; generative monitoring should remain meaningful even when no such formalism is used.

Proposition 11.370 (Generative monitoring adequacy). *Monitoring of generative consequence is adequate only to the extent that the selected observation objects correspond to an explicit account of how later capabilities, relations, institutions, action spaces, or history structures can be produced, preserved, depleted, or transformed.*

Proposition 11.370 guards against labeling any delayed indicator as generative. The defining feature is its relation to future-generating conditions, not simply its temporal horizon.

11.21.5 Early-Warning Indicators

Early-warning indicators seek observations that become practically informative before a consequential history fully manifests. Their role is to support attention, protective action, deeper inquiry, or revision while options remain available. They can be especially important where consequences are nonlinear, delayed, cascading, or difficult to reverse.

Definition 11.371 (Early-warning indicator). An *early-warning indicator* is an observation object whose change, configuration, or event pattern is treated as a precursor warranting specified practical attention before the corresponding adverse or transformative consequence is fully realized.

Early warning need not take the form of a scalar threshold. A warning can arise from a pattern of events, a change in network structure, the appearance of a previously absent relation, a loss of redundancy, a cluster of local reports, a change in model disagreement, or a shift in institutional responsiveness. Threshold rules remain useful when their semantics and error consequences are justified, but they are one possible warning architecture among several.

The event-ordered framework is useful here. A warning event can be defined partly through its position relative to later consequence events. Some precursors become meaningful because they repeatedly occur in the event past of a harmful transition, even when the elapsed clock duration varies across cases. Other warnings depend on event density, branching, or changes in precedence structure rather than on one time series.

Warning systems should record false positives, false negatives, delayed recognition, and strategic adaptation. Actors can change behavior once a warning rule becomes known. Institutions can also become desensitized when warnings are frequent but weakly connected to actionable response. An early-warning architecture should therefore connect observation to response capacity rather than maximize warning sensitivity independently of practical consequence.

Definition 11.372 (Warning-response pathway). A *warning-response pathway* connects an early-warning observation to the responsible position, interpretation procedure, verification or escalation step, protective or adaptive response, and subsequent review of whether the warning relation remained valid.

Without such a pathway, warning indicators can accumulate informational significance while producing little practical protection.

11.21.6 Distributional Indicators

Distributional indicators observe how consequences are allocated across affected positions rather than reporting only aggregate performance. Their methodological role is to connect monitoring with the power, participation, responsibility, and justice architectures developed in Chapter 10.

Definition 11.373 (Distributional indicator). A *distributional indicator* is an observation object designed to represent how a benefit, burden, exposure, risk, capability, voice opportunity, recovery condition, or future option is distributed across practically relevant positions, relations, or temporal horizons.

Distributional monitoring should not assume that all relevant positions are already represented in the dataset. A newly recognized affected subject can require the indicator architecture itself to change. Likewise, equal nominal access can conceal unequal activation cost, waiting capacity, exposure, or ability to obtain remedy. The unit of observation therefore depends on the justice question rather than on administrative convenience alone.

The same aggregate improvement can coexist with concentrated harm. Distributional indicators should preserve this possibility by retaining position-specific or relation-specific information where feasible. Aggregation can still be useful, but its weighting, grouping, and exclusion rules should remain visible.

Distribution can also be temporal. Present actors can receive benefits while future actors inherit maintenance burdens, reduced action spaces, or long-latency risks. Monitoring regimes should therefore link immediate distribution with longer-horizon carryover where the intervention plausibly creates such obligations.

A distributional indicator can itself create classification effects. Once eligibility, disadvantage, risk, or benefit is represented through a category, the category can shape access, institutional attention, identity, and strategic behavior. Distributional monitoring therefore leads directly to the performative questions of the next subsection.

11.21.7 Observer and Classification Effects

Observation can alter the field it seeks to describe. Measurement can redirect attention; disclosure can change expectations; ranking can reorganize incentives; classification can create eligibility or exclusion; and repeated observation can alter trust, participation, or strategic behavior. These effects should be represented as part of monitoring methodology rather than treated only as contamination of otherwise neutral data.

Definition 11.374 (Observer effect in applied monitoring). An *observer effect in applied monitoring* is a practically material change in behavior, relation, institution, representation, or later history generated by the presence, procedure, disclosure, interpretation, or anticipated consequences of observation.

Definition 11.375 (Classification effect). A *classification effect* is a practically material transformation generated when a category or classification is recognized, applied, contested, institutionalized, or anticipated by affected positions.

Observer and classification effects can be harmful, beneficial, or mixed. Visibility can create protection, recognition, or resource access while simultaneously increasing surveillance or strategic exposure. A public indicator can improve accountability while encouraging actors to optimize the indicator rather than the underlying objective. The relevant question is therefore which transformation the observation regime generates and whether that transformation is compatible with the practical purpose of monitoring.

The typed distinction of Equations 11.48 and 11.49 is especially important here. A classification first represented in an observation space can later acquire practical force through an uptake event. The pathway between the two should be traceable where it materially affects rights, resources, standing, burden, or intervention his-

tory.

Definition 11.376 (Observation-effect record). An *observation-effect record* documents the observation or classification event, uptake pathway, positions affected, represented transformation, expected and unexpected performative consequences, uncertainty, and any resulting revision to the monitoring regime.

Monitoring systems should therefore monitor themselves where the observation regime is materially performative. This reflexivity is not infinite self-observation; it is a proportionate requirement to inspect the consequences of observation when those consequences can alter the object or legitimacy of the intervention.

11.21.8 Action-Generated Evidence

Once action occurs, the resulting practical history generates evidence that could not have been observed in the same form before intervention. Implementation reveals interfaces, institutions adapt, affected subjects respond, and new constraints or capacities can become visible. Monitoring converts selected traces of this changing field into evidence for later practical inference.

Definition 11.377 (Action-generated evidence). *Action-generated evidence* is evidence whose availability, content, or practical meaning depends materially on an intervention, implementation process, or consequential practical event having occurred.

Action-generated evidence should be classified according to whether the intervention primarily *revealed*, *activated*, *created*, or *obscured* the observed condition. A latent dependency can be revealed when a service is interrupted. A dormant capability can be activated by a new coordination arrangement. A category or relation can be created through institutional recognition. A monitoring redesign can obscure comparison with earlier periods even while improving present measurement.

This classification matters for inference. Evidence generated by a new institution cannot automatically be interpreted as evidence that the same institutional relation existed before the intervention. Likewise, behavior observed after public disclosure can reflect adaptation to the observation regime rather than an unchanged underlying tendency.

Action-generated evidence should therefore retain intervention provenance. The record should preserve which intervention events preceded the observation, which representation produced the evidence, which positions were altered by implementation, and which alternative explanations remain live. This allows later sections on feedback and evaluation to distinguish evidence about the original model from evidence about the transformed field.

Proposition 11.378 (Action-generated evidence provenance). *Evidence generated through intervention is practically interpretable only to the extent that the history of intervention, implementation, observation, and performative uptake relevant to the evidence remains reconstructible enough to distinguish revelation, activation, creation, and obscuration.*

Proposition 11.378 gives action-generated evidence a disciplined role without assuming that intervention merely exposes a pre-existing static reality.

11.21.9 Unintended Effects

Unintended effects are consequential changes outside the intervention's expected or explicitly targeted history structure. They can be adverse, beneficial, ambiguous, or initially uninterpretable. Monitoring should therefore preserve the capacity to observe beyond the variables used to define expected success.

Definition 11.379 (Unintended effect). An *unintended effect* is a practically material change generated or mediated by intervention that was absent from, insufficiently represented in, or outside the expected consequence architecture of the operative intervention design.

Unintended effects can arise through spillovers, strategic adaptation, cross-scale propagation, subject transformation, institutional reinterpretation, observation effects, newly generated relations, or interaction with conditions excluded from the original model. Their absence from the design does not imply that they are causally unrelated to the intervention.

Monitoring should distinguish *unexpected* from *unintended*. A consequence can be expected but undesired; another can be intended but fail to occur; a third can be beneficial yet wholly unanticipated. This distinction improves both responsibility analysis and later model revision.

The event-ordered architecture helps reconstruct unintended effects where several pathways overlap. Rather than asking only whether an outcome occurred after intervention in calendar time, the analysis can examine which intervention, institutional, epistemic, and relational events lie in the represented event past of the consequence and which alternative pathways remain plausible.

An unintended effect can also create a new practical subject or affected position. For example, a new institution can generate a category of participants whose interests did not exist in the same form before implementation. Monitoring architecture should therefore permit revision of the affected-subject map rather than requiring every relevant position to have been specified *ex ante*.

Definition 11.380 (Unintended-effect register). An *unintended-effect register* records the observed effect, affected positions, relevant event history, plausible pathways, scale and depth, reversibility, uncertainty, distributional consequence, and the resulting implications for monitoring, intervention design, and practical closure.

The register is not limited to adverse events. Beneficial emergent effects can identify previously unknown generative mechanisms or action possibilities and can justify revision of the intervention's objectives or theory of change.

11.21.10 Data and Representation Updating

Monitoring produces observations inside representations that can themselves become inadequate as the practical field changes. Categories can lose validity, instrumentation can drift, data-generating processes can change after intervention, and newly recognized subjects can make earlier schemas incomplete. Monitoring methodology therefore requires explicit procedures for updating both data structures and practical representations.

Definition 11.381 (Monitoring representation version). A *monitoring representation version* is a documented configuration of categories, variables, observation channels, mappings, inclusion rules, uncertainty conventions, and interpretive assumptions used to construct monitoring evidence during a specified region of the practical history.

Versioning matters because a series can appear continuous even when its meaning changes. A revised eligibility category, sensor, survey wording, institutional classification, or affected-subject boundary can create a discontinuity in what is being observed. Treating the old and new representations as automatically comparable can create false trends or conceal substantive transformation.

Updating can occur at several levels. *Data updating* adds or corrects observations inside an existing representation. *parameter updating* changes model estimates. *schema updating* changes variables, categories, or relational objects. *boundary updating* changes who or what is represented. *structural updating* changes the model or generative relation used to interpret observations. *history-space updating* changes which future branches are represented as admissible or materially relevant.

Definition 11.382 (Representation bridge). A *representation bridge* is a documented mapping, correspondence, or qualified non-equivalence between two monitoring representation versions used to preserve whatever longitudinal comparison remains justified after the observation architecture changes.

A representation bridge can be exact, approximate, partial, or absent. Where important objects cannot be translated responsibly, the discontinuity should remain visible rather than being repaired through an arbitrary conversion. Raw provenance, original categories, and earlier model versions should be retained where possible so later re-epistemization can reconstruct what was known and how it was represented at the earlier stage.

Updating should also preserve disagreement. A new representation can improve fit for one purpose while reducing visibility for another. Alternative representations can therefore coexist for a period rather than being forced immediately into one schema. Model plurality and interpretive plurality remain relevant inside monitoring just as they do in diagnosis and decision analysis.

Proposition 11.383 (Monitoring representation revision). A *monitoring representation should be revised when materially relevant epistemic events, practical transformations, affected positions, observation effects, or validity failures make the existing representation inadequate for the decisions and responsibilities it is meant to support, with comparability preserved only to the extent that a justified representation bridge exists.*

Proposition 11.383 prevents longitudinal continuity from becoming a reason to preserve an obsolete observation regime.

11.21.11 Monitoring Burden

Monitoring consumes resources and can redistribute burden. Data collection requires time, attention, infrastructure, expertise, disclosure, participation, and institutional capacity. Observation can expose subjects to surveillance, classification,

administrative work, repeated consultation, or strategic risk. Monitoring design should therefore evaluate its own practical cost and relational consequences.

Definition 11.384 (Monitoring burden). A *monitoring burden* is a practically material cost, exposure, obligation, attention demand, privacy loss, classification effect, participation load, resource use, or relational consequence generated by the production, maintenance, interpretation, communication, or institutional use of monitoring evidence.

Monitoring burdens are distributed unevenly. Front-line actors can bear documentation work while central institutions receive analytical benefit. Affected subjects can repeatedly provide testimony without gaining corresponding influence. Data-intensive systems can centralize interpretive authority among actors with technical access. Automated monitoring can reduce some administrative burdens while increasing surveillance or dependence on proprietary infrastructure.

The marginal value of additional monitoring should therefore be considered together with its marginal burden. More observation is not automatically better. A dense monitoring system can consume the very capacity required for implementation, maintenance, care, or adaptation. It can also produce indicator fixation, where organizational attention shifts toward what is measured because it is measured.

Monitoring burden can alter the evidence being collected. Participants can withdraw, simplify reporting, strategically respond, or change behavior under persistent observation. Burden is therefore not merely an ethical externality; it can become part of the data-generating process and weaken epistemic quality.

Definition 11.385 (Monitoring proportionality). *Monitoring proportionality* is the requirement that the depth, frequency, granularity, intrusiveness, and resource intensity of observation remain proportionate to the practical decisions, uncertainties, risks, responsibilities, and revision capacities the monitoring regime is intended to support.

Proportionality can justify selective rather than exhaustive observation, rotating samples, event-triggered review, local data stewardship, privacy-preserving aggregation, participatory monitoring, or deliberate non-collection where observation would create disproportionate harm. The appropriate architecture depends on the practical field and cannot be inferred from data availability alone.

Monitoring should also have its own exit and revision conditions. Indicators can become obsolete, burdens can accumulate, and a once-useful observation regime can become institutionalized beyond its original justification. Periodic or event-triggered review should therefore ask whether the regime still observes the right objects, whether its categories remain valid, whether its performative effects remain acceptable, and whether some monitoring practices should be narrowed, redesigned, or retired.

Proposition 11.386 (Monitoring-regime adequacy). *A monitoring regime is adequate insofar as it produces decision-relevant and revisable observations of manifested, relational, generative, early-warning, and distributional consequences; preserves provenance and representation change; detects materially relevant unintended histories; represents the performative effects of observation itself; and maintains monitoring burdens proportionate to the practical responsibilities the regime is meant to support.*

Proposition 11.386 closes the observation block by treating monitoring as a reflexive practical architecture rather than a passive stream of measurements. Once observations begin to accumulate, the next methodological task is to determine how they alter models, history weights, intervention pathways, escalation or de-escalation conditions, and the action space itself. Section 304 therefore turns to feedback, reweighting, and adaptive revision.

11.22 Feedback, Reweighting, and Adaptive Revision

Section 11.21 developed monitoring as a reflexive observation regime embedded in an evolving practical field. The present section develops the methodological architecture through which monitored traces, action-generated evidence, warnings, and participant or institutional responses can alter subsequent praxis. Its role is to connect observation with revision while preserving the distinctions among feedback collection, interpretation, epistemic change, model updating, field transformation, strategy revision, action-space regeneration, resequencing, reversal, and exit. Its objective is to make adaptive revision responsive without making it mechanically reactive. The discussion proceeds from feedback collection and interpretation to epistemic events, threshold rules as a special case, model and operator updating, history reweighting, strategy revision, action-space regeneration, adaptive sequencing, and terminal or reversing responses.

Definition 11.387 (Adaptive feedback architecture). An *adaptive feedback architecture* is a versioned practical arrangement that connects observations and consequential traces to interpretation, epistemic updating, model or representation revision, strategy and sequencing changes, action-space revision, and where warranted reversal or exit, while preserving provenance, authority, uncertainty, affected positions, and the distinction between readout and transformation.

Adaptive feedback is therefore broader than a closed control loop. A practical system can receive an observation without revising anything; revise a model without changing the field; change a strategy without changing the intervention target; or performatively transform the field because an observation, classification, warning, or interpretation acquires institutional force. The architecture should preserve these differences rather than compressing them into one generic notion of response.

Table 11.22 summarizes the architecture. The dimensions can interact recursively. A feedback event can revise a model; the revised model can alter the represented history space; a newly represented branch can generate a new action; the new action can require resequencing; and the resulting intervention can produce further observations. Adaptive revision is therefore best represented as a governed historical process rather than a single update step.

11.22.1 Feedback Collection

Feedback collection begins when practical traces are selected for possible use in later revision. These traces can include monitoring indicators, participant testimony, implementation records, warnings, model residuals, institutional responses, mainte-

Table 11.22: Methodological dimensions of feedback, reweighting, and adaptive revision.

Dimension	Primary methodological object	Characteristic question
Feedback collection	Traces, reports, warnings, responses, and provenance	Which consequential signals enter the revision process, from which positions, and under which event conditions?
Feedback interpretation	Meaning, relevance, disagreement, and alternative explanations	What does the feedback support, and which interpretations remain unresolved?
Epistemic events and state change	Typed relation among readout, recognition, uptake, and transformation	Does the feedback revise knowledge, transform the field, or participate in both through distinct stages?
Threshold-based revision	Local trigger rule with explicit semantics and error costs	When is a threshold rule appropriate, and what does it omit from the wider revision architecture?
Model and operator updating	Parameters, structure, operator families, and validity regions	Which representation or transformation rule should change after the epistemic event?
History weights and transition kernels	Relative support, accessibility, propensity, or probability of histories	Which histories are reweighted, generated, or removed, and with what semantics?
Strategy updating	Objective, target, mechanism, scale, depth, timing, and safeguards	Which parts of the intervention strategy should change while preserving a traceable practical identity?
Action-space regeneration	Available, latent, generated, and foreclosed actions	Does feedback merely compare existing actions or change what can be done next?
Adaptive sequencing	Event order, precedence, stages, and branch structure	Which planned event relations should be added, removed, or reordered?
Reversal and exit	Rollback, repair, withdrawal, transfer, and residual obligations	When should adaptive revision give way to reversing or leaving the practical arrangement?

nance histories, complaints, failures, beneficial surprises, and changes in the action space. The methodological object is therefore wider than data collection in a narrow statistical sense.

Definition 11.388 (Practical feedback object). A *practical feedback object* is a trace, observation, report, response, event pattern, model discrepancy, or consequence selected as potentially relevant to the continuation, interpretation, revision, reversal, or termination of an intervention or decision pathway.

Feedback objects inherit the provenance requirements of Section 11.21. A useful record identifies the source position, observation or reporting procedure, relevant event history, representation version, uncertainty, access conditions, and any known performative effect associated with producing the feedback. A numerical indicator without these relations can be precise while remaining practically ambiguous.

Collection should also preserve feedback that does not fit the current model. Reports that appear anomalous, qualitative changes that lack an existing category, disagreement among affected subjects, or newly visible consequences can be especially important because they may indicate that the observation architecture or model boundary itself requires revision. Filtering feedback only through established variables can systematically exclude evidence of structural novelty.

The event-ordered temporal architecture developed in Section 11.16 is useful here. Feedback need not arrive on a uniform clock schedule. Some feedback objects become meaningful only after specified predecessor events; some are generated by newly opened branches; others arise concurrently from different positions and remain only partially ordered. A feedback collection plan should therefore record both clock-time labels where operationally necessary and the practical event relations that determine why an observation becomes relevant.

Definition 11.389 (Feedback provenance record). A *feedback provenance record* documents the feedback object, source position, generating event history, observation or reporting process, representation version, uncertainty, access conditions, relevant performative effects, and the practical question for which the feedback is being considered.

Feedback collection is selective by necessity. The appropriate objective is not exhaustive capture but sufficient visibility of the practical objects that can materially alter responsibility, safety, model adequacy, affected positions, intervention logic, or future option structures.

11.22.2 Interpretation of Feedback

Feedback does not determine its own practical meaning. A change in an indicator can represent intervention effect, contextual change, adaptation, measurement drift, reporting behavior, model misspecification, delayed consequence, or a combination of these. Interpretation connects the observed trace to one or more hypotheses about what has changed and why.

Definition 11.390 (Feedback interpretation profile). A *feedback interpretation profile* records the practical feedback object, candidate meanings or mechanisms, supporting and conflicting evidence, relevant model assumptions, affected positions, uncertainty, alternative interpretations, and the practical implications that would follow if each interpretation were provisionally accepted.

Interpretation should preserve the distinction among description, attribution, and practical implication. Observing that a relational indicator changed does not by itself establish which intervention mechanism generated the change. Establishing a plausible mechanism does not by itself determine whether the practical response should be continuation, redesign, deeper inquiry, protection, de-escalation, or exit. These inferential steps can require different evidence and different forms of judgment.

Multiple interpretations can remain live. Rather than forcing immediate convergence, the method can maintain an *interpretive feedback remainder*: materially relevant disagreements, anomalies, or unexplained traces that have not yet been responsibly absorbed into the dominant account. Such remainders can later become espe-

cially informative if subsequent events differentiate the competing explanations.

Interpretation can itself become performative. A public explanation of failure, a new institutional classification, or an official interpretation of a warning can change expectations, responsibility, legitimacy, reporting behavior, or resource allocation. The interpretation record should therefore distinguish the content of an interpretation from the practical consequences generated when that interpretation is recognized or institutionalized.

Proposition 11.391 (Feedback interpretation discipline). *Feedback should alter practical commitments only through an interpretation whose evidential basis, alternatives, uncertainty, affected positions, and practical implications are sufficiently explicit for later contestation and revision, with performative consequences of the interpretation recorded where they are materially relevant.*

Proposition 11.391 prevents responsiveness from collapsing into immediate reaction to whatever signal is most visible or institutionally salient.

11.22.3 Epistemic Events and State Change

Once feedback is interpreted, it can become an epistemic event in the sense developed in Section 11.4: a historically situated event that changes a practically relevant representation, claim, model, category, recognized position, or other condition of knowing. Some epistemic events remain within the epistemic architecture. Others become performatively coupled to changes in the practical field.

The typed distinction developed in Section 11.21 remains essential. Observation is a readout into a representation space; recognition or interpretation can revise the epistemic state; institutional uptake can then activate a separate transformation of the practical configuration. These stages can be related by event precedence without being identified with one another.

A schematic event-order relation among feedback, interpretation, and uptake is stated in Equation 11.50.

$$e_f \preceq e_i \preceq e_u, \quad (11.50)$$

where e_f denotes a feedback-producing event, e_i an interpretive or epistemic event, and e_u a possible uptake event. Equation 11.50 expresses precedence only where the practical history warrants it. The occurrence of e_f does not require either later event, and other events can intervene or remain incomparable in the partial order.

Definition 11.392 (Feedback-mediated epistemic coupling). *A feedback-mediated epistemic coupling is a traceable relation through which feedback contributes to an epistemic event and that epistemic event, through a distinct practical uptake pathway, alters a configuration, relation, institution, action space, transformation rule, or later history.*

This formulation allows feedback to have several different consequences. It may revise only a parameter estimate. It may change the model family used for interpretation. It may generate a new affected-subject category. It may alter an institutional rule. It may change which actions are reachable. It may also have no immediate

operational consequence while remaining preserved for later re-epistemization.

The distinction matters for responsibility. If a monitoring system produced a warning but no authorized position could interpret or act on it, the failure lies in a different part of the practical architecture than if the warning was interpreted and deliberately ignored. Adaptive revision should therefore preserve the event history connecting observation, interpretation, authorization, and transformation.

11.22.4 Threshold-Based Revision as a Special Case

Threshold rules remain useful when the relevant quantity, semantics, decision consequence, and error structure are sufficiently stable. Examples include safety limits, reserve requirements, operational tolerances, or pre-authorized escalation conditions. Their proper place is as one local revision architecture inside the broader framework.

A schematic threshold-based revision rule is stated in Equation 11.51.

$$\rho(z) = \begin{cases} \rho_0, & g(z) < \tau, \\ \rho_1, & g(z) \geq \tau, \end{cases} \quad (11.51)$$

where z is a represented feedback state, g a specified diagnostic function, τ a justified threshold, and ρ_0, ρ_1 the corresponding practical responses. Equation 11.51 is meaningful only after the semantics of g , the provenance of τ , and the practical consequences of classification around the threshold have been specified.

Definition 11.393 (Threshold revision profile). A *threshold revision profile* records the observation object, diagnostic function, threshold provenance, error consequences, affected positions, response associated with crossing or leaving the threshold region, hysteresis or persistence conditions where relevant, and conditions under which the threshold architecture itself should be revised.

Threshold rules can fail when the relevant change is structural rather than scalar, when the observation regime is performative, when the model family is unstable, when several values remain incompletely commensurable, or when the action space changes endogenously. They can also create strategic behavior once actors learn the rule. For these reasons, threshold crossing should not be treated as the general form of adaptive decision.

A threshold can nevertheless be embedded productively inside a richer architecture. For example, crossing a warning threshold can activate deeper inquiry rather than automatically trigger intervention; crossing a safety threshold can constrain an action space while leaving the final response to deliberation; or different thresholds can govern escalation and de-escalation to reduce unstable switching. The methodological question is therefore what practical role the threshold performs.

11.22.5 Model and Operator Updating

Feedback can change the representation used to understand the field or the represented transformation rules through which intervention is expected to operate. These updates should be distinguished. A model can change while the practical field remains approximately the same; the field can change while an obsolete model

remains institutionally dominant; or an epistemic event can revise both the model and the practical operator family through performative uptake.

A model-and-operator update can be represented schematically by Equation 11.52.

$$(\mathcal{M}', \mathfrak{A}') = \mathcal{U}^{\text{fb}}(\mathcal{M}, \mathfrak{A}; F, e_i, \omega), \quad (11.52)$$

where F denotes the interpreted feedback record, e_i the relevant epistemic event, $\mathcal{M}$ the current model architecture, and $\mathfrak{A}$ a model-specific family of available or represented transformations. Equation 11.52 is intentionally schematic: the update can be statistical, qualitative, structural, operator-algebraic, institutional, or hybrid depending on the model family.

Definition 11.394 (Feedback-driven model revision). A *feedback-driven model revision* is a versioned change to parameters, variables, boundaries, structural relations, model family, validity region, or model plurality architecture justified by interpreted feedback and preserved together with the earlier model and the evidence that triggered revision.

Operator updating is equally plural. An epistemic event may change the parameterization of an existing transformation, remove an operator from the admissible family, generate a new operator, alter composition rules, or change the domain on which an operator can act. In institutional settings, this can correspond to a new permission, prohibition, capability, interface, or procedural rule.

Updating should preserve disagreement where model comparison remains unresolved. Several models can continue in parallel if they support different aspects of the field or if the evidence is insufficient to justify replacement. Adaptive revision therefore inherits the model-plurality discipline of Section 11.12 rather than forcing every feedback event into one canonical representation.

11.22.6 History-Weight and Transition-Kernel Updating

Where the model represents families of future histories, feedback can alter the relative support assigned to those histories. It can also change the transition structure through which later configurations become reachable. These two operations should remain distinct from changing the history space itself.

A general nonnegative reweighting architecture is stated in Equation 11.53.

$$W'(h) = \mathcal{R}^{\text{fb}}[W, F, e_i, \mathcal{M}'](h), \quad h \in \mathcal{H}', \quad (11.53)$$

where W is a model-specific history-weight function and $\mathcal{H}'$ is the currently represented admissible history family. Equation 11.53 does not assign probabilistic semantics automatically. The weight can represent probability, plausibility, accessibility, transition propensity, simulation mass, or another explicitly defined quantity.

When transition kernels have genuine probabilistic semantics, feedback can instead update a conditional kernel. Where those semantics are absent, the same practical role can be represented through a nonnegative transition potential or another model-specific relation. Normalization should follow the semantics of the model rather than being imposed merely because a mathematical object resembles

a probability kernel.

Definition 11.395 (Feedback-induced history revision). A *feedback-induced history revision* is a documented change in history weights, transition relations, admissible branches, or the represented history space generated by interpreted feedback, with the semantics of the updated quantities and the reason for the structural change kept explicit.

An epistemic event can therefore produce at least three different history-level responses. It can *reweight* histories already represented; it can *change transition structure* among represented configurations; or it can *transform the history space* by generating or removing branches. The third case is especially important in GR because feedback can reveal new actions, create new institutional pathways, identify previously unrecognized subjects, or make an earlier branch practically impossible.

The same distinction applies to amplitude-like models where they are independently justified. Feedback can modify amplitudes or the set of histories over which amplitudes are defined, but the additional semantics required for complex-valued quantities remain those established in Section 11.12. Adaptive revision does not by itself provide those semantics.

11.22.7 Strategy Updating

Model revision does not automatically imply strategy revision, and strategy revision need not wait for complete model replacement. Strategy updating concerns changes to the organized practical pathway through which an objective is pursued under current knowledge and institutional conditions.

Definition 11.396 (Strategy revision profile). A *strategy revision profile* records which elements of an intervention strategy change after feedback, including where relevant objective, criteria, target, mechanism, timing, scale, depth, enabling conditions, safeguards, monitoring, sequencing, authority, and exit architecture, together with the justification, uncertainty, and consequences for the practical identity of the intervention.

Strategy revision can be narrow or deep. A narrow update can adjust dosage, staffing, communication, or review frequency while preserving the target and mechanism. A deeper update can change the target layer, alter the mechanism, move intervention across scales, reduce depth, modify the objective, or replace the strategy entirely. Deeper revisions generally require stronger reauthorization because they can change which positions are affected and what the intervention substantively is.

Revision should also avoid overreaction to noisy feedback. The appropriate response can be continued observation, replication, triangulation, or a temporary protective measure rather than immediate redesign. Conversely, insisting on stability for the sake of comparability can preserve an intervention after its mechanism or context has materially changed. Strategy governance therefore requires a balance between continuity and responsiveness.

Definition 11.397 (Strategy version). A *strategy version* is a time- and event-indexed record of the intervention's objective, target, mechanism, scale, depth, sequencing, safeguards, monitoring, and authority configuration used to preserve the provenance

of adaptive change across the practical history.

Versioning protects evaluation from treating several materially different strategies as one unchanged intervention. It also supports responsibility by preserving which actors authorized which version under which epistemic conditions.

11.22.8 Action-Space Regeneration

Feedback can change the action space as well as the assessment of actions already present within it. Section 11.10 defined action-space regeneration as the generation or restoration of practical possibilities through changes in knowledge, capacity, institutions, relations, or other enabling conditions. The present subsection places that process inside the feedback architecture.

Feedback can *reveal* a latent action that had been omitted from the decision frame. It can *generate* a new action through knowledge, coordination, capability formation, legal authorization, or institutional redesign. It can *restore* an action previously foreclosed by reversible constraints. It can also *foreclose* an action when new evidence reveals unacceptable risk, when resources are consumed, or when the historical field changes irreversibly.

Definition 11.398 (Feedback-to-action-space pathway). A *feedback-to-action-space pathway* documents how interpreted feedback changes the status, reachability, activation conditions, cost, legitimacy, or existence of one or more practical actions, including the epistemic and institutional events through which the change occurs.

This pathway should distinguish discovery from generation. Learning that an action was already possible is different from creating the capacity, institution, relation, or permission that makes the action possible for the first time. The distinction matters for causal attribution and for later evaluation of whether the intervention increased practical agency.

Action-space regeneration can itself be a deliberate response when every currently reachable option is inadequate. Rather than select the least harmful existing action, adaptive praxis can invest in creating another option. This can require capability building, trust repair, negotiation, infrastructure, institutional redesign, or further inquiry. Feedback therefore can redirect praxis from *choosing among actions* toward *generating conditions for new action*.

11.22.9 Adaptive Sequencing

When feedback changes the represented field, the planned order of intervention events can also require revision. Adaptive sequencing concerns changes to precedence, staging, branch conditions, and coordination relations in the intervention plan while preserving the event-ordered temporal architecture established in Section 11.16.

A sequence plan should be understood as a planned partial order rather than necessarily a total list. Feedback can add a new prerequisite event, remove a previously required event, introduce a new branch, change the order between two dependent actions, or leave formerly ordered events incomparable when the earlier precedence claim is no longer justified.

Definition 11.399 (Adaptive resequencing record). An *adaptive resequencing record* documents the earlier event-order plan, the feedback and epistemic events that triggered revision, added or removed precedence relations, generated or closed branches, altered stage boundaries, operational clock-time implications where relevant, and consequences for authority, evaluation, reversibility, and responsibility.

Resequencing can change the meaning of later stages. A participation process inserted before design can transform the design object itself. A capability-building stage inserted before delegation can change who is capable of exercising delegated authority. A new protective stage can preserve options that would otherwise be foreclosed. These are generative changes in the history rather than administrative adjustments to a timetable.

Adaptive sequencing should also preserve path dependence. Once some events have occurred, the original sequence cannot simply be restored by editing the remaining plan. Earlier commitments, disclosures, classifications, investments, or relational changes become part of the realized history. Resequencing therefore begins from the transformed field actually inherited at the revision event.

11.22.10 Reversal and Exit

Adaptive revision eventually reaches cases in which continuation through modification is less appropriate than reversal, termination, withdrawal, transfer, or exit. These responses should remain distinct from ordinary strategy updating because they change the relation between the intervention and the practical field more fundamentally.

Definition 11.400 (Adaptive reversal condition). An *adaptive reversal condition* is a specified or newly recognized practical condition under which rollback, restoration, repair, termination, or transition away from an implemented intervention becomes more supportable than continued adaptation of the existing pathway.

Reversal can be triggered by severe adverse consequences, failure of an essential assumption, loss of legitimacy, inability to maintain protective conditions, mechanism failure, unacceptable distributional effects, emergence of a substantially safer alternative, or exhaustion of the institutional capacity required for responsible continuation. The trigger can be threshold-based, pattern-based, deliberative, model-comparative, or event-structural depending on the practical object.

Exit concerns the relation of a subject, institution, or participating position to the practical arrangement. It can involve withdrawal from a program, transfer of responsibility, termination of a role, or release from a dependency. Formal exit remains inadequate where the practical capacity to leave is absent or where departure transfers severe residual burdens to those who remain.

Reversal and exit are therefore historical processes rather than instantaneous switches. They can require predecessor events such as notification, capability transfer, data handoff, infrastructure transition, compensation, repair, or restoration of alternatives. They can also leave irreversible residues: disclosed information, changed expectations, institutional precedent, sunk infrastructure, or transformed subject positions.

Definition 11.401 (Adaptive closure record). An *adaptive closure record* documents the feedback history, interpreted reasons, authorization, reversal or exit pathway, residual obligations, irreversible consequences, preserved records, affected positions, and reopening conditions associated with ending or fundamentally reversing an intervention pathway.

The possibility of reversal and exit should feed back into earlier design. Interventions that preserve rollback capacity, institutional memory, transferability, and alternatives can remain adaptively governable for longer than interventions that consume the very capacities required to leave them.

Proposition 11.402 (Adaptive-revision adequacy). An *adaptive revision architecture* is adequate insofar as it preserves the provenance and interpretation of feedback; distinguishes epistemic updating from practical transformation; treats thresholds as local tools rather than universal decision rules; revises models, operators, history weights, strategies, action spaces, and event sequences at the level warranted by the feedback; and maintains credible pathways for reversal, exit, and responsible closure when continued adaptation is insufficient.

Proposition 11.402 closes the adaptive-feedback block. Monitoring and revision keep an intervention epistemically and practically responsive while it unfolds, but they do not by themselves establish whether the intervention has achieved its intended or emergent effects across manifested, relational, structural, historical, and generative dimensions. Section 305 therefore turns to evaluation methodologies.

11.23 Evaluation Methodologies

Section 11.22 developed feedback and adaptive revision as a versioned process through which observations, interpretations, epistemic events, model updates, history reweighting, action-space changes, and practical responses can alter an intervention while it unfolds. The present section develops the complementary methodology of evaluation. Its role is to reconstruct what an intervention has generated across manifested, relational, historical, structural, institutional, capability, constraint, option-space, and history-space dimensions without reducing practical significance to one endpoint or one metric. Its objective is to distinguish immediate outcome assessment from broader generative evaluation while preserving attribution limits, event-order structure, affected positions, uncertainty, and the possibility that the intervention changes the evaluative objects themselves. The discussion proceeds from immediate and relational effects through subject, downstream, delayed, structural, capacity, and constraint effects, then examines option-space, history-space, generative, and historically situated evaluation.

Definition 11.403 (Practical evaluation architecture). A *practical evaluation architecture* is a versioned arrangement for reconstructing and judging intervention-relevant changes across specified objects, positions, histories, scales, and horizons while preserving the intervention history, observation regime, criteria, uncertainty, alternative explanations, affected positions, and revision conditions associated with each evaluative claim.

Evaluation therefore has at least three separable tasks. It reconstructs *what*

Table 11.23: Methodological dimensions of intervention evaluation.

Dimension	Primary evaluative object	Characteristic question
Immediate outcomes	Manifested conditions and near-term outputs	What changed close to the intervention event, and relative to which reference or expectation?
Relational effects	Dependence, authority, trust, information, recognition, and coordination	Which relations were created, weakened, intensified, redistributed, or made more fragile?
Subject/entity change	Historical-relational constitution, capability, standing, and internal organization	How did affected subjects or entities themselves change through the intervention history?
Downstream effects	Propagated consequences across relations, positions, and scales	Which consequences appeared beyond the focal target or immediate recipients?
Delayed effects	Consequences separated from intervention by event chains or clock duration	Which effects emerged only after intervening processes, accumulation, or latency?
Structural effects	Recurrent organization, topology, roles, and institutionalized pathways	Did the intervention alter the structures that reproduce later practical conditions?
Capacity effects	Sensing, interpretation, coordination, implementation, repair, learning, and revision	Which capacities were created, restored, depleted, concentrated, or made dependent?
Constraint effects	Restrictive, protective, constitutive, and substituted constraints	Which constraints changed, for whom, and what new constraints were generated elsewhere?
Option-space effects	Available, latent, generated, restored, and foreclosed actions	How did the intervention change what affected positions can later do, refuse, revise, or recover from?
History-space effects	Branches, admissible histories, transition structures, and weights	Which future histories became more accessible, less accessible, newly possible, or impossible?
Generative effects	Conditions for later valued generation and responsible adaptation	What capacities, relations, institutions, and future possibilities did the intervention enable or erode?
Historical evaluation	As-of warrant, realized consequences, later evidence, and reinterpretation	How should the intervention be evaluated across changing knowledge states without hindsight distortion?

changed; it evaluates the practical significance of that change relative to specified criteria and affected positions; and, where warranted, it examines how the intervention participated in generating the observed change. These tasks can draw on different evidence and methods. A strong descriptive change does not by itself establish causal attribution, and a plausible causal attribution does not by itself establish that the change was normatively desirable, fairly distributed, sustainable, or generatively beneficial.

Table 11.23 summarizes the evaluative layers. The layers are analytically distinguishable but can be historically coupled. An immediate output can modify a relation; the relational change can alter a subject's capability; the capability change can generate a new action; the new action can open a history branch; and the resulting institutional trajectory can later transform the criteria by which the intervention is evaluated. Evaluation is therefore a reconstruction of an evolving practical history rather than a terminal reading of a fixed outcome variable.

Definition 11.404 (Evaluation claim profile). An *evaluation claim profile* records the evaluative object, relevant intervention and observation events, comparison basis, criteria, affected positions, evidential support, model or interpretive assumptions, alternative explanations, uncertainty, scope, and practical implication associated with an evaluative claim.

The profile is useful because different evaluative claims can have different eviden-

tial standing within the same intervention. A near-term output may be measured precisely while a structural or long-horizon generative claim remains provisional. The methodology should preserve this asymmetry rather than allowing the precision of one indicator to lend unwarranted certainty to the entire evaluation.

11.23.1 Immediate Outcomes

Immediate-outcome evaluation concerns changes observed close to the focal intervention events in the relevant practical ordering. The phrase *immediate* is relational before it is chronometric. An outcome can be immediate because it directly follows a specified intervention event in the represented event structure even when the associated clock duration is long; conversely, a rapid numerical change may be only indirectly related to the intervention if several relevant practical processes intervene.

Definition 11.405 (Immediate outcome profile). An *immediate outcome profile* records the near-term manifested conditions or outputs associated with an intervention, the predecessor intervention events, observation regime, comparison basis, affected positions, criterion version, uncertainty, and attribution status.

Immediate-outcome evaluation can use before–after comparison, matched comparison, experimental estimates, interrupted histories, qualitative reconstruction, process evidence, or other locally justified methods. The selection of method depends on the intervention architecture and the available comparison relations. A strong evaluation should state whether the comparison concerns a reference history, a counterfactual model, a contemporaneous comparison group, an earlier stage, or another explicit basis.

Immediate outcomes are especially important for safety, stabilization, implementation verification, and early-stage adaptive decisions. They can determine whether a pilot remains within its protection envelope, whether a staged intervention should continue, or whether an unexpected consequence requires immediate response. Their practical importance does not make them sufficient for broader evaluation.

A recurring error is to treat the first observable success variable as the intervention's evaluative object. If a program increases measured access, for example, evaluation may still need to examine whether actual use, dependency, trust, maintenance burden, institutional capability, or later option space changed in the intended way. Section 11.21 distinguished immediate indicators from relational and generative indicators for this reason.

Immediate outcomes can also be performative. Publicizing an early success indicator can generate expectations, legitimacy, investment, imitation, or strategic behavior that changes the later intervention field. Evaluation should therefore record whether the outcome remained merely observed or became an epistemic event whose uptake altered subsequent history.

Remark 11.406 (Outcome precision and evaluative scope). High precision in an immediate outcome estimate strengthens claims about the represented outcome under the stated design; it does not by itself strengthen claims about relational, structural, generative, historical, or normative effects that require additional objects and inferential pathways.

11.23.2 Relational Effects

Relational evaluation examines whether intervention changes the relations through which later practical conditions are generated. Relevant relations can include dependence, authority, information flow, trust, recognition, care, coordination, exchange, conflict, representation, accountability, and exit. A relational effect can be substantively important even when the immediate attributes of the participating positions change little.

Definition 11.407 (Relational effect profile). *A relational effect profile records the relation under evaluation, involved positions, pre-intervention and post-intervention relational configurations, relevant event history, direction and intensity of change where meaningful, distributional consequences, uncertainty, and plausible intervention pathway.*

Relational effects should not be inferred solely from convenient proxies. Communication frequency can increase while trust declines; formal participation can increase while influence remains concentrated; resource transfer can increase while dependency deepens. Evaluation therefore benefits from combining observation, participant interpretation, institutional records, network or higher-order representations where appropriate, and explicit reconstruction of how the relation operates.

The effect can also be asymmetric. An intervention can reduce one position's dependence while increasing another's burden of coordination or care. It can increase institutional visibility while reducing safe exit. Relational evaluation should therefore identify the relevant direction of the relation and the positions from which it is experienced.

Some relational effects are constitutive of later intervention performance. Trust, coordination, or recognition generated during a pilot can make scale-up possible; surveillance, resentment, or representational distance can make later implementation fragile. Relational effects are therefore both evaluative outcomes and possible mechanisms in later histories.

Proposition 11.408 (Relational evaluation principle). *Where the represented mechanism of an intervention depends materially on relations among positions, adequate evaluation requires direct or inferential assessment of those relations rather than relying exclusively on attributes of the participating positions or aggregate outputs.*

11.23.3 Subject and Entity Transformation

Interventions can transform the subjects and entities that later participate in the practical field. The relevant subject is the historical-relational object developed throughout this chapter rather than a fixed preference-bearing point. Evaluation should therefore ask whether capability, standing, internal organization, recognized identity, constitutive relations, institutional roles, or practical memory changed through the intervention history.

Definition 11.409 (Subject-transformation evaluation). *A subject-transformation evaluation reconstructs intervention-relevant changes in the historical-relational constitution of a subject or entity, including changes in capability, standing, internal organization, constitutive relations, event history, institutional position, and future*

practical agency.

Where useful, the subject can be represented through a partial order of events, a labeled 2-complex, a relational history, a network with internal structure, or another model that preserves the relevant historical organization. The evaluation should not infer ontological identity from the representation. Its purpose is to make explicit which parts of the subject's historical-relational structure are claimed to have changed.

Subject transformation can be enabling. Capability formation, recognition, restored standing, new organizational memory, or collective agency can expand later action spaces. It can also be constraining. Classification, dependency, role fixation, surveillance, or institutionalization can narrow later possibilities or make exit costly.

The evaluator should also distinguish transformation from selection. If an intervention appears to improve the average capability of participating subjects because less-capable participants leave, the observed composition change differs from genuine capability formation. Similar distinctions arise between identity transformation and reclassification, between collective-agency generation and replacement of participants, and between institutional learning and staff turnover.

Subject transformation can alter the meaning of subsequent outcomes. A later choice made by a more capable or differently constituted subject cannot always be evaluated as though it were the choice of the pre-intervention subject under new options. This is one reason longitudinal evaluation should preserve subject-history versions rather than assume a time-invariant unit of analysis.

11.23.4 Downstream Effects

Downstream effects are consequences that propagate beyond the focal target, immediate recipients, or first-order mechanism through relational, institutional, material, informational, or historical pathways. They can occur at the same representational scale or cross several scales.

Definition 11.410 (Downstream consequence pathway). A *downstream consequence pathway* is a documented or model-supported sequence of relational, institutional, material, epistemic, or generative events through which an intervention-relevant change propagates from a focal target toward later affected positions or practical configurations.

Downstream evaluation should preserve the event path rather than merely correlate the initial intervention with a later condition. A pathway can include mediation, amplification, attenuation, substitution, strategic response, institutional adaptation, or interaction with another intervention. The degree of warranted attribution can vary along the path.

A useful evaluation distinguishes at least three cases. A downstream effect can be *mechanistically anticipated* by the intervention design; it can be *plausibly linked but unanticipated*; or it can be *observed downstream while its relation to the intervention remains unresolved*. These statuses should not be collapsed.

Propagation can also redistribute rather than simply add effects. A local burden can be displaced to another organization, community, time horizon, or maintenance

system. Apparent local success can therefore coexist with downstream cost transfer. Multiscale evaluation should make these transfers visible where they are material.

The downstream pathway can itself generate new epistemic events. A consequence first observed outside the focal intervention boundary may force boundary revision and reveal that the original target map was too narrow. Evaluation then becomes a source of practical diagnosis for subsequent cycles.

11.23.5 Delayed Effects

Delayed effects are consequences whose practical manifestation occurs only after intervening events, accumulation, adaptation, maintenance failure, institutional succession, or another latency process. Under the event-ordered conception of time developed in Section 11.16, delay is not defined solely by elapsed clock duration.

Definition 11.411 (Evaluative delay relation). An *evaluative delay relation* records the intervention event or event family, the downstream consequence event, the intervening event structure or latency process, optional clock-time labels where relevant, and the uncertainties connecting the earlier intervention to the later manifestation.

Some delayed effects are predictable from known lags; others appear only because the intervention transforms the conditions through which later events unfold. A training intervention, for example, can produce no immediate organizational change until authority is delegated later. Infrastructure can appear successful until deferred maintenance accumulates. A classification can have little immediate effect but later become embedded in institutional routines and eligibility rules.

Continuous-time or discrete-time delay models remain available where appropriate, but they are special representations. In a partial-order history, an effect can be delayed because several generatively necessary events lie between the intervention and consequence even if a single scalar duration is not meaningful.

Delayed evaluation requires preservation of institutional memory. If the original intervention rationale, design version, uncertainty, and affected positions are lost, later consequences can become detached from the historical conditions needed to interpret them. Evaluation therefore depends on the provenance and handoff architectures developed in Chapters 10 and 11.

A long delay also complicates responsibility. Personnel, institutions, rules, and environmental conditions can change between intervention and manifestation. Evaluation should distinguish historical causal participation from current responsibility for monitoring, repair, continuation, or compensation.

11.23.6 Structural Effects

Structural evaluation examines recurrent organization rather than isolated states. Relevant structures can include role configurations, network topology, access pathways, infrastructures, recurring dependencies, standards, higher-order relations, and institutionalized patterns that reproduce practical conditions across events.

Definition 11.412 (Structural effect profile). A *structural effect profile* records intervention-relevant changes in recurrent relational organization, including topol-

ogy, role structure, access pathways, infrastructure, repeated dependencies, persistence, affected positions, and the mechanisms through which the changed structure reproduces later practical conditions.

Structural change should be distinguished from repeated state change. A program can repeatedly transfer resources while leaving the access structure unchanged; another intervention can modify the access rule so that later transfers occur differently without repeated discretionary action. The second case is structurally deeper even if its immediate output appears modest.

Evaluation should also preserve the useful functions carried by the earlier structure. A restructuring can reduce one harmful dependency while unintentionally eliminating redundancy, institutional memory, care relations, or rapid coordination. Section 11.18 emphasized this problem when discussing intervention depth. Structural evaluation therefore examines both removed and regenerated functions.

The persistence of structural effects matters. A formally changed structure can revert through informal adaptation; a temporary workaround can become institutionalized through repeated use. Evaluation should therefore distinguish formal structural change, enacted structural change, and durable structural reproduction.

Where formal models are used, structural effects can be represented through network or higher-order changes, altered operator composition, changed access graphs, or other model-specific structures. Their practical interpretation still requires historical and institutional reconstruction.

11.23.7 Capacity Effects

Capacity evaluation asks what affected positions become able to sense, interpret, decide, coordinate, implement, maintain, repair, learn, contest, or revise after intervention. Capacity is relationally activated and should not be inferred solely from resource possession.

Definition 11.413 (Capacity effect profile). A *capacity effect profile* records the practical capacity under evaluation, relevant resources and activation relations, pre-intervention and post-intervention reachability, distribution across positions, maintenance requirements, dependence on external support, decay or regeneration conditions, and implications for later action.

The profile should distinguish *temporary performance* from *durable capacity*. Extraordinary staffing, emergency funding, consultant support, or unusual political attention can generate high performance during a pilot without creating an institution that can reproduce the capability under ordinary conditions. Conversely, early performance can remain modest while a new training, coordination, or memory architecture gradually creates durable capacity.

Capacity can also become concentrated. An intervention may increase total technical capability while making other positions increasingly dependent on one provider, one model, one infrastructure, or one institutional gatekeeper. Evaluation should therefore examine distribution, redundancy, substitutability, and the ability of affected subjects to exercise the capacity independently or collectively.

Capacity loss is equally important. Automation, centralization, outsourcing, or rule

simplification can reduce the need for some local skills until those skills disappear. The immediate intervention can appear efficient while future repair or adaptation capacity declines. Such effects belong to generative evaluation even if they are not visible in the primary outcome metric.

11.23.8 Constraint Effects

Constraint evaluation examines how intervention changes the restrictions, protections, permissions, dependencies, and constitutive boundaries that shape later practical possibility. The evaluative object includes both the removal of constraints and the creation or redistribution of new ones.

Definition 11.414 (Constraint effect profile). A *constraint effect profile* records the constraint type, affected positions, pre-intervention and post-intervention operation, protective or constitutive function where relevant, modifiability, substitution or displacement, interaction with capacities, and consequences for later practical agency.

A reduction in one constraint can create another. Removing a procedural requirement can reduce delay while increasing exposure to error or weakening contestability. Expanding access to a digital service can reduce spatial barriers while creating data, device, identity, or literacy constraints. Constraint evaluation should therefore look for *constraint substitution* and *constraint transfer* across positions and scales.

Protective and constitutive constraints require special care. Rights, safety limits, reserves, due-process requirements, and ecological boundaries can restrict immediate action while preserving future agency or preventing irreversible harm. Evaluating an intervention as successful because it “removed friction” can therefore be misleading if the removed constraint carried a protection that has not been replaced.

Constraint effects are often coupled with capacity effects. A formal restriction can become less significant when capability increases; a nominal permission can remain unusable when activation capacity is absent. Evaluation should therefore avoid treating constraints and capacities as independent scalar quantities.

11.23.9 Option-Space Effects

Option-space evaluation asks how intervention changes the actions that affected positions can later reach, generate, refuse, revise, sequence, or recover. It builds directly on the evolving action-space framework of Sections 11.7 and 11.22.

Definition 11.415 (Option-space effect profile). An *option-space effect profile* records intervention-relevant changes in available, latent, generated, restored, and foreclosed actions, together with the capacities, constraints, authority, knowledge, relations, costs, and event histories that explain the change in practical reachability.

Option-space evaluation should distinguish *discovery* from *generation*. Recognizing an action that was already reachable differs from creating the capability, legal authorization, institution, relation, or infrastructure that makes an action newly possible. The difference matters for both attribution and evaluation of generative value.

Foreclosure can be harmful or protective. An intervention can eliminate harmful actions through safety rules or rights protections; it can also destroy alternatives, exit

routes, local capabilities, or future design branches. Evaluation therefore examines which options were foreclosed, for whom, through whose authority, and with what possibility of later restoration.

Option-space effects are particularly important where immediate outcomes look similar across interventions. Two interventions can achieve comparable current performance while leaving radically different future possibilities. One can preserve modularity, learning, and exit; another can generate lock-in. A terminal outcome comparison would miss this difference.

A useful evaluative record therefore asks whether the intervention increased future *agency* or merely increased the number of nominal options. Effective options require the capacities and conditions needed for meaningful exercise.

11.23.10 History-Space Effects

History-space evaluation examines how intervention changes the set, structure, or relative support of possible future histories. It is broader than option-space evaluation because a history can differ through institutional evolution, subject transformation, exogenous events, coordination patterns, or generative-rule changes even when the immediately available action set appears unchanged.

Definition 11.416 (History-space effect profile). A *history-space effect profile* records whether an intervention reweights represented histories, alters transition structure, creates or removes branches, changes admissibility, modifies event precedence, transforms generative rules, or changes the representation required to describe later histories.

Where a model supports history weights, an evaluation can compare model-specific pre-intervention and post-intervention weight structures. This does not require probabilistic semantics. The weights can represent accessibility, plausibility, transition propensity, simulation mass, or another explicitly defined quantity. The key evaluative question is whether the intervention changed the relative practical support of later histories and how that claim is warranted.

History-space transformation is stronger than reweighting. A new institution can generate a branch that did not previously exist in the model; a rule change can make an earlier branch inadmissible; a performative epistemic event can change actor expectations and thereby create new coordination histories. In such cases, comparing weights on a fixed history space would misrepresent the intervention.

The event-ordered conception of history is especially useful here. Evaluation can ask whether the intervention added new event types, changed predecessor relations, generated alternative branch points, or made formerly incomparable events dependent. A labeled 2-complex or other partially ordered representation can make these transformations explicit where appropriate.

History-space evaluation should remain model-plural. Different models may disagree about which branches exist or how they should be weighted. Such disagreement belongs in the evaluation rather than being hidden by selecting one model after the fact.

11.23.11 Generative Effects

Generative evaluation asks what the intervention changes about the capacity of the practical field to produce later valued conditions, responsible agency, learning, repair, coordination, and revision. It integrates but does not collapse the preceding evaluative layers.

Definition 11.417 (Generative effect). A *generative effect* is an intervention-relevant change in the conditions through which later capabilities, relations, institutions, knowledge, options, histories, values, or forms of agency can be generated, sustained, regenerated, revised, or foreclosed.

Generative effects are not equivalent to long-term effects. A consequence can occur far in the future without changing the field's generative organization, while a near-term change in trust, institutional memory, classification, or capability can immediately alter many later possibilities. The defining issue is whether the intervention changes the conditions of later generation.

Generative evaluation can therefore examine, among other objects, capability formation, institutional self-revision, relational regeneration, maintenance capacity, protected dissent, knowledge production, option creation, repairability, and preservation of future epistemic agency. It can also identify negative generative effects such as lock-in, dependence, concentrated control, loss of local knowledge, erosion of repair capacity, or narrowing of future action spaces.

Definition 11.418 (Generative evaluation profile). A *generative evaluation profile* records the later-generating conditions altered by an intervention, the event and relational pathways through which the alteration occurred, the affected positions, temporal and scale horizons, durability, uncertainty, enabling or constraining effects on future agency, and the relation between the generative effect and the intervention's stated or emergent objectives.

Generative evaluation should preserve heterogeneity. Increasing one kind of generative capacity can reduce another. Centralization can increase rapid coordination while weakening local experimentation. Standardization can improve interoperability while narrowing plural forms of knowledge. Automation can increase processing capacity while eroding human maintenance or interpretive capability. These effects need not be forced into one scalar index.

The methodology should also distinguish *generated value* from the later economics-specific theory of heterogeneous value transmission, conversion, return, capture, and justice developed in the substantive GRE parts. At this stage, generative evaluation provides the general praxis architecture required for those later economic questions.

Proposition 11.419 (Generative evaluation principle). *Evaluation of application-dominant praxis is generatively adequate only when it examines, where materially relevant, how the intervention changes the conditions under which later subjects and institutions can generate, sustain, contest, repair, and revise practical possibilities, rather than evaluating only the manifested endpoint of the original intervention.*

11.23.12 Historical Evaluation

Historical evaluation reconstructs an intervention across changing epistemic, institutional, and relational states. Its central methodological problem is to evaluate realized consequences without rewriting the earlier decision as though later knowledge had already been available.

Definition 11.420 (Historical evaluation dossier). A *historical evaluation dossier* preserves the intervention's as-of practical state, including the evidence, models, uncertainty, criteria, affected positions, action space, authority, dissent, expected histories, and revision conditions available at the relevant decision event, together with the realized intervention history, later evidence, consequences, reinterpretations, and subsequent revisions.

Historical evaluation therefore contains at least two different questions. The first asks whether the earlier decision or intervention was warranted relative to the information, values, authority, and alternatives reasonably available at that historical position. The second asks what consequences actually followed and what should now be learned, repaired, revised, or reassessed. The answers can differ.

A harmful realized consequence can reveal a serious model failure or an ignored warning; it can also arise from a genuinely unforeseeable event under an earlier decision that was proportionately warranted. Likewise, a favorable outcome does not retroactively establish that the earlier reasoning was sound. Ex ante warrant and ex post consequence should therefore remain historically distinguishable.

The event-ordered architecture supports this distinction naturally. Each evaluative claim can be indexed to an *as-of event*: the latest epistemic and practical events that were legitimately available to the relevant decision position. Later events belong to the evaluator's historical future relative to that decision and should not be silently imported into its justification.

Definition 11.421 (As-of evaluation state). An *as-of evaluation state* is the reconstructed practical and epistemic configuration associated with a specified historical event, including the information, models, action space, institutional conditions, values, and uncertainty that were available or reasonably accessible at that point.

Historical evaluation also permits re-epistemization. Later concepts, models, archives, testimony, or evidence can produce a richer reconstruction of the intervention and its consequences. This later reconstruction should remain connected to the earlier as-of state so that reinterpretation does not become hindsight substitution.

A further issue is criterion drift. The values or evaluation criteria applied later may differ from those formally used at the original decision. Later evaluation can legitimately criticize earlier criteria, but the evaluation should distinguish *historical reconstruction of the earlier criterion architecture* from *present normative reassessment*. Both can be important; they answer different questions.

Proposition 11.422 (Historical-evaluation adequacy). *Historical evaluation is adequate insofar as it preserves the event-ordered distinction between earlier as-of warrant and later realized consequence; reconstructs changes in evidence, models, criteria, institutions, subjects, and action spaces; permits later re-epistemization without hindsight substitution; and retains enough provenance for practical learning, responsibility,*

repair, and revision to remain contestable.

Proposition 11.422 closes the evaluation block. Evaluation can establish that an intervention achieved some objectives, generated valuable capacities, transferred burdens, altered subjects, foreclosed options, or transformed the history space. It can also reveal that the intervention failed to operate as intended, that its mechanism was misidentified, or that repair is now required. Section 306 therefore develops failure detection and repair as a distinct methodological architecture.

11.24 Failure Detection and Repair

Section 11.23 developed evaluation as the reconstruction of intervention histories across immediate, relational, historical, structural, capacity, constraint, option-space, history-space, generative, and later re-epistemized effects. The present section develops the methodology required when that reconstruction indicates that an intervention, implementation process, model, institution, protection architecture, or generative pathway is failing to perform an intended or required practical function. Its role is to distinguish failure detection from retrospective outcome description and to connect failure signals to diagnosis, protection, repair, compensation, institutional learning, and revision. Its objective is to preserve the event-ordered and relational architecture established throughout this chapter while avoiding the inference that every adverse outcome falsifies an intervention theory or that every nominally successful output demonstrates practical adequacy. The discussion proceeds from failure criteria and early signals through failure as an epistemic event, unintended and perverse effects, harm detection, repair and compensation, institutional learning, and revision after failure.

Definition 11.423 (Practical failure). A *practical failure* is a materially relevant divergence between the realized or emerging intervention history and a specified practical function, protection condition, mechanism requirement, criterion, responsibility, or generative condition, under an explicitly stated scope and historical position.

Definition 11.423 makes failure relational and criterion-indexed. An intervention can achieve one objective and fail another. A mechanism can function while implementation fails. A program can satisfy its immediate output criterion while degrading future capability or violating a protected condition. Conversely, an adverse event can occur even where the intervention remains broadly adequate, especially when the event lies outside the warranted control or prediction envelope. Failure analysis therefore requires localization rather than immediate totalization.

Definition 11.424 (Failure localization profile). A *failure localization profile* records the practical layer at which a suspected failure occurs, the relevant criterion or function, the event history through which the divergence became visible, affected positions, alternative explanations, uncertainty, propagation pathways, and the response options available at the time of diagnosis.

Table 11.24 summarizes the section's diagnostic architecture. The layers can overlap. A representation failure can produce implementation error; institutional fragmentation can suppress an early warning; a mechanism failure can become a generative failure after repeated commitment; and a failure to learn can reproduce an

Table 11.24: Methodological layers of failure detection and repair.

Layer	Characteristic diagnostic question	Potential response
Criterion failure	Did the intervention cease to satisfy a stated or protected practical condition?	Clarify criterion, protect affected positions, reassess continuation.
Signal failure	Were warning events absent, ignored, misclassified, or disconnected from response?	Redesign observation and escalation pathways.
Mechanism failure	Did the represented generative pathway fail to operate as expected?	Reconstruct mechanism, revise model or intervention logic.
Implementation failure	Did execution diverge from the intended intervention architecture?	Repair capability, coordination, sequencing, or operational conditions.
Representation failure	Did categories, measurements, models, or boundaries obscure the relevant process?	Re-epistemize the problem and revise the observation/model architecture.
Institutional failure	Did mandate, authority, accountability, memory, or coordination fail to support responsible action?	Repair or redesign institutional relations and responsibility pathways.
Harm realization	Did the intervention generate or amplify materially relevant harm?	Protect, contain, repair, compensate, and reassess commitment.
Generative failure	Did later capability, repairability, option space, or responsible agency deteriorate?	Restore generative conditions and reconsider intervention depth or rule structure.
Learning failure	Did the institution preserve consequences without changing future praxis?	Convert findings into memory, rules, capability, and review architecture.
Revision failure	Did the intervention remain unchanged after materially relevant evidence or failure?	Escalate revision, reversal, or exit pathways.

earlier harm in a later institutional generation. Failure analysis therefore follows the historical path of divergence rather than assigning one label solely from the final outcome.

11.24.1 Failure Criteria

Failure detection begins with a criterion architecture. The relevant criterion can concern objective attainment, safety, justice, institutional legitimacy, mechanism operation, implementation fidelity, capability preservation, reversibility, maintenance, participation, or another protected practical condition. A failure criterion should therefore state what function is being assessed and why divergence from that function matters.

Definition 11.425 (Failure criterion). A *failure criterion* is a versioned practical condition whose violation, deterioration, or persistent non-attainment provides warranted grounds for diagnosing a specified mode of failure, subject to stated uncertainty, observation conditions, and response implications.

A failure criterion differs from a success metric. Success criteria often ask whether an intended effect occurred. Failure criteria can also identify unacceptable side effects, loss of protective conditions, disappearance of repair capacity, institutional breakdown, or destruction of future options. An intervention can therefore cross a failure criterion even while its headline output continues to improve.

Failure criteria can be threshold-based where the practical object warrants a threshold. They can also be relational, structural, event-pattern, or qualitative. A protective criterion may be violated by the appearance of an unauthorized relation; a mechanism criterion may fail when a required predecessor event does not occur; a generative criterion may fail when capability or option-space contraction persists despite acceptable current output. The criterion architecture developed in Section 11.3 therefore remains broader than scalar cutoffs.

Definition 11.426 (Failure-criterion profile). A *failure-criterion profile* records the criterion, practical object, protected or intended function, affected positions, observation method, uncertainty, temporal or event-order scope, severity, required response, authority for interpretation, and conditions for criterion revision.

Failure criteria should be established before avoidable harm where possible, yet they remain revisable. New epistemic events can reveal that an earlier criterion was insensitive to a relevant relation, subject, time horizon, or history-space effect. Revision should preserve the earlier criterion version so that historical evaluation can reconstruct what the institution was actually capable of detecting at each stage.

Proposition 11.427 (Failure-criterion adequacy). A *failure criterion* is *practically adequate* insofar as it identifies a materially relevant function or protection condition, connects that object to an observation and response pathway, preserves uncertainty and affected positions, and remains revisable without erasing earlier versions or shifting the criterion solely to protect the intervention from adverse evaluation.

11.24.2 Early Failure Signals

Early failure signals are observations or event patterns that provide reason to investigate emerging failure before the full consequence structure is realized. Their value lies in preserving time, reversibility, repair capacity, and future options. They are therefore closely related to the early-warning architecture of Section 11.21, while failure detection gives them a more specific diagnostic and response role.

Definition 11.428 (Early failure signal). An *early failure signal* is an observed event, relation, pattern, divergence, or structural change that materially increases the practical relevance of a specified failure hypothesis before failure is fully manifested or conclusively attributed.

The definition is intentionally weaker than a failure conclusion. A signal should trigger attention, checking, protection, or diagnostic escalation appropriate to its severity; it does not automatically establish the cause. Repeated local complaints, declining maintenance capacity, increasing implementation variance, disappearing redundancy, a newly concentrated dependency, or divergence between observation sources can all function as early signals without independently proving a complete failure mechanism.

Signals are especially important in event-ordered histories. A predecessor event can be practically significant even before a terminal adverse outcome occurs. If a protective review event fails to occur before an irreversible commitment, the missing event itself can be an early failure signal. Likewise, a branch in the realized intervention history can disclose that the intervention has entered a region where earlier protection assumptions no longer apply.

Definition 11.429 (Failure-signal pathway). A *failure-signal pathway* records the signal event or pattern, observation source, interpretation, responsible review position, protective or diagnostic response, escalation conditions, and the later outcome of the signal assessment.

Signal systems can themselves fail. Warnings may be unobserved, inaccessible, suppressed, normalized, or disconnected from authority. A technically accurate mon-

itoring system therefore provides little protection if those who receive a signal lack standing or capacity to alter the intervention. Failure detection should evaluate the complete signal-to-response pathway rather than the existence of indicators alone.

Early signals can also create false alarms. The appropriate response depends on the cost of checking, the potential severity and reversibility of the suspected failure, the quality of the signal, and the possibility that the observation process itself is performative. The methodology therefore favors proportionate escalation over automatic intervention.

11.24.3 Failure as Epistemic Event

Recognition of failure can itself become an epistemic event. A realized divergence can expose a missing mechanism, omitted subject, incorrect boundary, false assumption, inadequate model, neglected institutional relation, or unforeseen generative consequence. Failure can therefore change what is known about the intervention and, through institutional uptake, can also change the field in which later action occurs.

Definition 11.430 (Failure epistemic event). A *failure epistemic event* is a failure-relevant event whose recognition materially changes a practical representation, model, uncertainty structure, criterion, subject map, action space, history-space representation, or other epistemic condition relevant to subsequent praxis.

The typed distinction developed in Section 11.4 remains important. A failure event can first be observed through a readout, testimony, record, evaluation, or model discrepancy. Recognition and interpretation can then revise the epistemic architecture. A later organizational or practical response can transform authority, resource allocation, monitoring, intervention sequencing, or the field itself. These events can be causally and institutionally connected while remaining analytically distinct.

Failure can generate evidence without uniquely identifying its cause. A realized adverse outcome can be compatible with a mistaken mechanism, implementation breakdown, contextual change, strategic response, measurement failure, or interaction among several factors. The methodology should therefore treat failure as an opening for discriminating inquiry rather than as automatic falsification of the highest-level theory associated with the intervention.

Definition 11.431 (Failure decomposition). A *failure decomposition* is a structured reconstruction that distinguishes, where relevant, failures of problem formulation, evidence, model, mechanism, target selection, timing, scale, depth, implementation, coordination, institution, observation, evaluation, maintenance, or generative consequence, together with their possible interactions and unresolved attribution.

Failure decomposition also protects against the opposite error: explaining away every adverse result as implementation noise. If repeated failures occur across competent implementations, the mechanism, target, model, criterion, or institutional architecture may require deeper revision. The evidential pattern across failures can itself become a higher-order epistemic event.

Remark 11.432 (Failure and theory revision). A failure can justify parameter revision, model revision, theory revision, intervention redesign, institutional repair, or a

return toward research-dominant praxis. The warranted depth of revision depends on where the failure is localized and how strongly alternative explanations remain supported.

11.24.4 Unintended Consequences

Unintended consequences are effects that were not part of the intervention's operative intention or design expectation. They can be beneficial, harmful, mixed, or initially indeterminate. Their methodological importance lies in revealing the limits of the original intervention model and the broader generative field in which the intervention operates.

Definition 11.433 (Unintended consequence profile). An *unintended consequence profile* records the consequence, affected positions, relation to the intervention history, whether the consequence was anticipated in any model or scenario, plausible generative pathways, severity, reversibility, uncertainty, distribution, and implications for monitoring, repair, revision, or future design.

An unintended consequence should be distinguished from an unexpected consequence. A consequence can be anticipated as possible yet remain unintended. Conversely, a beneficial emergent effect may be unexpected but compatible with the intervention's broader orientation. The distinction helps evaluation preserve both design intention and actual historical generation.

Unintended consequences can expose omitted relations or scales. A local intervention may transfer administrative burden to another organization; a protective classification may stigmatize a subject; a new monitoring system may improve visibility while changing trust; an efficiency reform may reduce slack needed for repair. These effects can occur without failure of the focal mechanism. They still belong to the intervention's practical consequence structure.

Unintended effects can also generate new options. An unplanned coordination relation, learned capability, or institutional routine can create a useful branch that the original intervention did not represent. Repair-oriented methodology should therefore avoid assuming that every departure from design is an error to be removed.

Proposition 11.434 (Unintended-consequence discipline). *Unintended consequences should be incorporated into intervention evaluation and revision according to their actual relational and historical significance, rather than being classified as failure merely because they were absent from the original design or excluded from consideration merely because the intended mechanism succeeded.*

11.24.5 Perverse Effects

A perverse effect is a more specific form of unintended consequence in which an intervention contributes to conditions opposed to one of its own important objectives, protections, or generative requirements. The term should be used carefully because an effect can appear adverse under one criterion while remaining beneficial under another.

Definition 11.435 (Perverse effect). A *perverse effect* is an intervention-relevant consequence through which the intervention's mechanism, implementation, represen-

tation, institutional uptake, or adaptive response contributes materially to deterioration in a practical condition that the intervention was intended or required to protect, improve, or sustain.

Perverse effects often emerge through feedback. A metric introduced to improve performance can redirect effort toward the metric while degrading the underlying practice. A protective procedure can become so burdensome that affected subjects lose access. A centralization intended to improve coordination can weaken local sensing and produce slower detection of failure. Such effects can be relational and generative even when immediate output measures remain favorable.

The mechanism of reversal matters. Some perverse effects arise because actors adapt strategically to a rule. Others arise through crowding out, path dependence, classification effects, resource displacement, loss of redundancy, or institutional overload. The response should therefore target the generating relation rather than merely correcting the final indicator.

Definition 11.436 (Perverse-effect pathway). A *perverse-effect pathway* reconstructs the event and relational sequence through which an intervention-relevant process contributes to deterioration in a protected or intended practical condition, including mediators, adaptive responses, affected positions, uncertainty, and possible repair points.

A perverse effect can also transform later histories by creating distrust, defensive behavior, exit, workaround institutions, or new dependencies. Detecting such history-space effects early can preserve more repair options than waiting for the final objective to deteriorate visibly.

11.24.6 Harm Detection

Harm detection concerns consequences serious enough to require protective attention regardless of whether the intervention has yet been judged a failure in a broader sense. The methodological priority is to identify affected positions, severity, propagation, reversibility, and immediate protection needs while preserving uncertainty about final attribution where necessary.

Definition 11.437 (Harm detection profile). A *harm detection profile* records the manifested or credibly emerging harm, affected positions, observation and testimony sources, event history, severity, reversibility, propagation risk, alternative explanations, intervention-relevance, immediate protective needs, and responsible response positions.

Harm can be material, relational, institutional, epistemic, procedural, capability-related, or generative. Loss of standing, concentrated dependence, destruction of repair capacity, silencing of local knowledge, or irreversible option foreclosure can be materially important even when they are poorly represented by immediate output metrics.

The protection response can precede complete causal attribution. If a severe and reversible exposure can be reduced while investigation continues, the practical architecture can justify protective action without claiming that the causal question has already been settled. Such action should preserve provenance and remain propor-

tionate to uncertainty, urgency, and the consequences of both protection and non-protection.

Definition 11.438 (Protective response envelope). A *protective response envelope* specifies the temporary protective actions permitted after a harm signal, their scope, authority, affected positions, reversibility, monitoring, evidential purpose, review event, and conditions for continuation, modification, or withdrawal.

Harm detection should also examine reporting asymmetry. Positions with limited institutional access, time, safety, language, technical standing, or credibility can experience harm earlier than central monitoring systems register it. Participatory and local-knowledge interfaces therefore remain part of harm detection rather than optional supplements.

A harm report can itself be a high-stakes epistemic event. Its treatment can alter trust, participation, organizational legitimacy, and willingness to report future failures. The process for receiving and responding to harm consequently becomes part of the intervention's generative architecture.

11.24.7 Repair

Repair is the practical attempt to restore, regenerate, or replace conditions damaged by intervention failure or harmful consequences. Repair should be distinguished from returning an indicator to its earlier value. The relevant object can be a relation, capability, institution, subject position, history-space branch, or condition of future agency that requires reconstruction rather than numerical correction.

Definition 11.439 (Repair target). A *repair target* is the damaged or degraded practical condition whose restoration, regeneration, substitution, or protective reconfiguration is intended to reduce the consequences of failure and recover responsible future praxis.

Repair targets can include manifested conditions, relations, trust, standing, infrastructure, capacity, institutional memory, accountability, observation quality, protected options, or rule architecture. The appropriate repair depth depends on the failure decomposition. Repeated replacement of an immediate output can remain inadequate where the generating relation continues to reproduce the damage.

Definition 11.440 (Repair pathway). A *repair pathway* is an event-ordered and responsibility-linked sequence of protective, restorative, relational, institutional, epistemic, or generative actions intended to address a specified repair target while preserving uncertainty, affected positions, monitoring, and conditions for further revision.

The event-order conception is particularly useful for repair. Stabilization may need to precede investigation; acknowledgment may need to precede trust repair; restoration of capability may need to precede withdrawal of external support. Other repair actions can proceed concurrently where no precedence relation is required. The repair pathway should therefore preserve dependency relations without forcing a single total schedule.

Repair can be reparative and generative at the same time. Restoring a damaged option can also create new institutional capacity for future detection. Rebuilding trust

can improve later coordination. Redesigning an accountability pathway can reduce recurrence. These effects should be evaluated explicitly rather than treating repair as mere return to a prior state.

Definition 11.441 (Repair remainder). A *repair remainder* records losses, harms, relational changes, irreversible residues, unresolved claims, or capability deficits that remain after the feasible repair pathway has been implemented.

The repair remainder matters because many histories cannot be reset. Disclosed information cannot be undisclosed; elapsed time cannot be restored; an institutional precedent can persist; trust can remain altered; a branch can remain foreclosed. Recognition of such residues prepares the compensation and exit architectures developed here and in Section 307.

11.24.8 Compensation

Compensation addresses losses or burdens that cannot be fully repaired, restored, or prevented. It should remain conceptually distinct from repair because replacement of a resource does not necessarily restore the relation, history, standing, capability, or opportunity that was lost.

Definition 11.442 (Practical compensation). *Practical compensation* is a response that transfers resources, rights, services, recognition, opportunities, capabilities, or other practical support toward affected positions in relation to intervention-associated loss or burden that remains after prevention and feasible repair.

Compensation can be material or non-material. Financial transfer can matter, but so can restored access, service provision, formal acknowledgment, procedural remedy, capability support, protected opportunity, or institutional reform. The appropriate form depends on the loss and the position of the affected subject.

Definition 11.443 (Compensation fit profile). A *compensation fit profile* records the loss or burden, affected position, degree of reparability, proposed compensation form, conversion conditions required for the compensation to become practically usable, distribution, timing, residual loss, and relation to responsibility and institutional reform.

Compensation should not become a license for preventable harm. A practical system can be poor at repair yet efficient at transferring payments after damage. Such an architecture can leave the underlying generative mechanism unchanged. Compensation therefore belongs within a broader response that includes prevention, repair, learning, and revision where relevant.

The distributional architecture also matters. Compensation can be difficult to access, delayed, conditional on burdensome proof, or unequally convertible into actual recovery. Evaluation should therefore distinguish nominal compensation from effective restoration of capability, standing, or opportunity.

Some losses remain incommensurable with the available compensation. The methodology should preserve the residual claim rather than represent a completed transfer as full equivalence. This point will become especially important in the later substantive GRE treatment of heterogeneous value transmission, conversion, return, and justice.

11.24.9 Institutional Learning

Institutional learning occurs when failure-generated knowledge changes the durable capacities through which an institution later senses, interprets, decides, acts, monitors, repairs, and revises. A report, inquiry, or after-action review can preserve information without producing institutional learning if the findings do not alter future practical architecture.

Definition 11.444 (Institutional learning from failure). *Institutional learning from failure* is a durable transformation of institutional memory, capability, rules, roles, observation regimes, responsibility pathways, or intervention methods that is traceably connected to a reconstructed failure history and improves the institution's capacity for later responsible praxis.

Learning can occur at several levels. A local implementation lesson may change a procedure. Repeated signal failure can redesign monitoring and escalation. A mechanism failure can require a new model. A representation failure can change categories or data architecture. A recurring institutional failure can change mandates, authority, or accountability. These levels should be distinguished because learning at the wrong level can leave the generating problem intact.

Definition 11.445 (Failure-learning record). A *failure-learning record* links the failure decomposition, relevant evidence, affected positions, adopted interpretation, institutional change, responsible positions, implementation status, later evaluation, and unresolved alternatives or disagreements.

Institutional learning requires memory continuity. Personnel turnover, organizational restructuring, vendor change, or political transition can sever the relation between failure and later practice. The learning record should therefore remain connected to roles, systems, and recurrent review processes rather than to the memory of particular individuals alone.

Learning also requires contestability. An institution can institutionalize an incorrect lesson from failure. Alternative interpretations, dissent, and unresolved causal claims should therefore remain accessible. Later evidence may reveal that an initially plausible lesson targeted the wrong mechanism.

Proposition 11.446 (Failure-learning adequacy). *Institutional learning from failure is adequate insofar as the organization preserves the failure history and affected positions, converts warranted lessons into durable practical capability or governance change, retains alternative interpretations where uncertainty remains, and evaluates whether the adopted change reduces recurrence without generating new failures elsewhere.*

11.24.10 Revision after Failure

Revision after failure integrates the preceding methodology. Its purpose is to determine how deeply the practical architecture should change once failure signals, harm, unintended or perverse effects, repair results, compensation limits, and institutional learning have been reconstructed. Revision should be matched to the localized failure rather than defaulting either to minimal parameter adjustment or to total abandonment.

Definition 11.447 (Failure-responsive revision architecture). A *failure-responsive re-*

vision architecture is a versioned arrangement that links a reconstructed failure to the depth and scope of practical change required in criteria, representation, model, target, mechanism, timing, scale, intervention depth, implementation, institution, monitoring, repair, compensation, or closure conditions.

The revision can occur at several levels. A parameter can change while the mechanism remains stable. A sequence can be reordered. A target or scale can be revised. A model or observation regime can be replaced. The intervention's depth can be reduced or increased. Institutional authority can be redistributed. A protected criterion can be strengthened. The action space can be regenerated. A severe or repeated failure can justify reversal or exit.

A useful discipline is to preserve the difference between *failure correction* and *failure accommodation*. Correction attempts to address the process that generated the failure. Accommodation modifies the surrounding system so that the failure becomes tolerable or less visible while the generating process remains. Accommodation can be legitimate where correction is infeasible or disproportionate, but its status should remain explicit.

Definition 11.448 (Failure revision trigger). A *failure revision trigger* is an epistemic, practical, institutional, or protective event whose occurrence satisfies the predeclared or subsequently warranted conditions for reconsidering a specified component of the intervention architecture.

Repeated failure can also indicate that application-dominant praxis has reached an epistemic limit. Where competing explanations, unknown mechanisms, unstable models, or unresolved historical relations become central, a bounded return toward research-dominant praxis may be more responsible than repeated operational adjustment. The recoupling architecture developed in Section 280 of Chapter 10 provides the conceptual basis for such a move, even when the surrounding institution continues to act on other parts of the problem.

Revision after failure should preserve the event history of earlier decisions. A later redesign does not erase the obligations created by the earlier intervention, including residual harm, compensation, repair, documentation, or responsibility. Versioning therefore connects adaptive change to accountability.

Proposition 11.449 (Failure-responsive revision principle). *Revision after failure is practically adequate insofar as the depth and object of revision correspond to the best-supported failure localization; affected positions, harm, uncertainty, and irreversible residues remain explicit; repair and compensation obligations survive redesign where relevant; and the revised architecture preserves credible pathways for further learning, reversal, and exit.*

Proposition 11.449 establishes the transition from repair-oriented adaptation to the stronger possibility that continuation of the intervention is no longer justified. Section 307 therefore develops exit and rollback as distinct practical architectures for ending, reversing, transferring, or re-entering intervention pathways while preserving residual responsibilities and historical effects.

11.25 Exit and Rollback

Section 11.24 developed failure detection and repair for cases in which an intervention, implementation process, representation, institution, or generative pathway diverges from a required practical function. The present section develops the stronger methodological architecture required when ordinary revision or repair no longer provides an adequate basis for continuation. Its role is to distinguish exit, rollback, partial reversal, withdrawal, transfer, residual responsibility, post-exit observation, and later re-entry as historically related but analytically different practical operations. Its objective is to preserve the event-ordered and relational conception developed throughout this chapter: leaving an intervention does not erase the events through which it altered subjects, relations, institutions, expectations, knowledge, and future possibilities. The discussion therefore proceeds from conditions for exit and rollback through reversibility and partial reversal, then develops orderly withdrawal, residual obligations and historical effects, post-exit monitoring, and re-entry.

Definition 11.450 (Exit architecture). An *exit architecture* is a versioned practical arrangement specifying the conditions, authority, event order, capability, transfer, protection, residual responsibility, observation, and reopening provisions through which an actor, institution, intervention, or governing arrangement can cease, withdraw from, transfer, or terminate a continuing practical commitment.

Definition 11.451 (Rollback architecture). A *rollback architecture* is a versioned practical arrangement specifying which implemented transformations are intended to be reduced, undone, restored, repaired, or replaced, together with the authority, event order, resources, reversibility limits, residual effects, and post-rollback observation required to carry out that change responsibly.

Definitions 11.450 and 11.451 distinguish two objects that are often compressed into one idea of termination. Exit changes a relation of participation, operation, authority, or support. Rollback targets one or more transformations already produced by the intervention. An actor can exit while the intervention remains in place under another authority; an intervention can be rolled back while the institution responsible for it remains active; and both can occur together. The distinction is necessary because the capacities, obligations, and residual consequences associated with each operation can differ substantially.

Table 11.25 summarizes the section's architecture. The dimensions should be read as coupled. A loss of reversibility can alter exit conditions; withdrawal can generate new residual obligations; rollback can create new harms requiring repair; post-exit monitoring can generate epistemic events that justify re-entry; and re-entry occurs in a field already transformed by the earlier intervention and exit history. Exit and rollback are therefore historical processes rather than administrative endpoints.

11.25.1 Exit Conditions

Exit becomes methodologically relevant when continuation of a practical relation is no longer sufficiently warranted, feasible, legitimate, safe, or responsible under the current architecture. The relevant relation can concern implementation, funding, participation, authority, service provision, governance, data operation, institutional

Table 11.25: Methodological dimensions of exit and rollback.

Dimension	Primary practical object	Characteristic methodological question
Exit conditions	Continuing participation, operation, authority, or support	Which developments justify ending or transferring the present practical relation?
Rollback conditions	Implemented transformations and their consequences	Which transformations should be reduced, undone, restored, or replaced, and with what authority?
Reversibility	Recoverability of affected configurations and capabilities	Which parts of the intervention remain practically reversible, by whom, and for which affected positions?
Partial reversal	Selective restoration amid irreversible residue	Which components can be reversed while others remain historically embedded?
Orderly withdrawal	Event-ordered transition out of active involvement	Which handoffs, protections, transfers, and predecessor events are required before withdrawal?
Residual obligations	Duties surviving operational exit	Which repair, compensation, memory, maintenance, data, or responsibility obligations continue afterward?
Residual effects	Relations and historical structures remaining after exit	Which dependencies, expectations, categories, institutions, or foreclosed branches remain in the field?
Post-exit monitoring	Observation after withdrawal or rollback	Which delayed, redistributed, or residual effects remain decision-relevant after active involvement ends?
Re-entry	Later renewed participation in a changed field	Under which new conditions can re-entry occur without treating the earlier history as erased?

support, or another continuing form of involvement. Exit should therefore be indexed to the practical relation being ended rather than treated as one generic project-closure event.

Definition 11.452 (Exit condition). An *exit condition* is a specified or newly recognized practical development under which ending, transferring, or terminating a continuing relation of participation, operation, authority, support, or exposure becomes sufficiently warranted to require active consideration or implementation.

Exit conditions can arise from failure, completion, loss of legitimacy, changed mandate, unacceptable harm, capability collapse, institutional succession, exhaustion of a time-bounded commitment, emergence of a superior arrangement, disappearance of the original problem, or inability to preserve the protections on which continued action depended. They can also arise from success. A temporary intervention can properly exit because the capability it was intended to create has become self-sustaining.

An exit condition should be distinguished from an exit signal. A signal increases the relevance of an exit hypothesis; a condition provides a practical basis for serious consideration or activation of exit. The difference permits early warning and protective preparation without forcing premature withdrawal from every uncertain intervention.

Definition 11.453 (Exit-condition profile). An *exit-condition profile* records the practical relation at issue, triggering event or development, affected positions, evidential basis, uncertainty, authority, urgency, available alternatives, transfer or handoff requirements, expected residual effects, and the conditions under which the exit decision itself should be revised.

Exit conditions should be established in advance where foreseeable, especially

when continuation can generate lock-in or dependence. Yet the architecture must remain open to newly recognized conditions. An intervention can reveal an affected subject omitted from the original design; an institution can lose the competence on which delegation depended; a monitoring regime can become harmful; or a new alternative can make continued exposure unnecessary. These events can justify revising the original exit logic.

The distribution of exit capacity also matters. The actor authorized to leave may differ from those who bear the consequences of departure. A funder can terminate support more easily than dependent service users can reconstruct the lost capability. A platform can discontinue an infrastructure while participants retain data, workflow, or contractual dependencies. The exit condition should therefore be evaluated from multiple affected positions rather than solely from the standpoint of the exiting actor.

Proposition 11.454 (Exit-condition adequacy). *An exit condition is practically adequate insofar as it identifies the relation being ended, connects the triggering development to affected positions and available alternatives, represents transfer and residual consequences, and preserves sufficient authority, capability, and revision pathways for an orderly transition rather than treating departure itself as completion of responsibility.*

11.25.2 Rollback Conditions

Rollback concerns implemented transformation rather than participation alone. Its object can be a rule, infrastructure, classification, data practice, institutional arrangement, resource commitment, technical system, relational configuration, or another intervention-produced change. Rollback becomes relevant when continuation or ordinary modification of that transformation is less supportable than reduction, restoration, replacement, or deliberate reconstruction.

Definition 11.455 (Rollback condition). *A rollback condition is a specified or newly recognized practical development indicating that one or more implemented transformations should be actively considered for reduction, restoration, replacement, termination, or reconstruction, subject to the actual reversibility and residual-consequence profile of the affected field.*

Rollback conditions can include material harm, mechanism failure, loss of legal or institutional authorization, unacceptable distributional consequences, erosion of generative capacity, newly discovered model failure, loss of monitoring or repair capability, or evidence that the intervention is producing a history substantially outside its warranted commitment envelope. A rollback condition can also arise before realized harm if the intervention loses the protective conditions on which its original warrant depended.

Rollback should not be equated with mechanical inversion. Suppose an intervention transformation is represented by Φ and produces the later configuration $\omega' = \Phi(\omega)$. A practical rollback operation Ψ generally satisfies Equation 11.54 rather than restoring the original configuration exactly.

$$\Psi(\Phi(\omega)) \neq \omega. \quad (11.54)$$

Equation 11.54 expresses historical non-restoration rather than a universal algebraic theorem. Between Φ and Ψ , subjects can learn, information can be disclosed, expectations can change, institutions can adapt, alternatives can disappear, and new relations can form. A formal inverse may therefore be unavailable, institutionally infeasible, normatively inappropriate, or practically meaningless even where a technical rollback procedure exists.

Definition 11.456 (Rollback-condition record). A *rollback-condition record* documents the target transformation, triggering event, affected positions, rollback objective, feasible restoration depth, event-order dependencies, capability and authority requirements, expected residual effects, repair or compensation needs, uncertainty, and post-rollback monitoring conditions.

Rollback can itself generate harm. Removing a system can interrupt services; reversing a classification can create administrative uncertainty; restoring an earlier rule can reactivate an older injustice; dismantling infrastructure can destroy capability that became valuable independently of the original intervention. The method should therefore compare the consequence histories of continuation, ordinary revision, rollback, replacement, and exit rather than treating rollback as a costless default once failure is detected.

11.25.3 Reversibility

Reversibility is the practical capacity that makes rollback more than a nominal promise. It depends on technical design, institutional authority, retained resources, records, alternative infrastructure, repair capability, affected-position protections, and the historical depth of adaptation around the intervention. A technically undoable operation can become practically irreversible if no authorized actor possesses the resources or standing to reverse it.

Definition 11.457 (Exit–rollback reversibility profile). An *exit–rollback reversibility profile* records, for each materially relevant intervention component and affected position, the degree of recoverability, authority to reverse, required predecessor events, resources, alternative capacity, expected duration, residual effects, repair burden, and the conditions under which reversibility is expected to decay.

Reversibility is positional. The institution can restore its own configuration while affected subjects remain unable to recover lost opportunity, disclosed information, damaged trust, or altered standing. Conversely, an affected subject can exit a service while the provider remains locked into infrastructure or contractual commitments. The profile should therefore avoid describing an intervention as simply “reversible” without identifying for whom and with respect to what object.

Reversibility is also event-ordered. A rollback operation can require preservation of records before data migration, capability transfer before support withdrawal, institutional authorization before infrastructure restoration, or repair before termination. Some requirements can remain concurrent, while others form strict generative precedence relations. Clock time can label these events where operationally useful,

but the practical architecture is determined by the predecessor relations required for credible recovery.

Definition 11.458 (Reversibility reserve). A *reversibility reserve* is the set of resources, authority, records, capabilities, alternatives, infrastructure, institutional memory, and protected practical options intentionally preserved so that rollback, withdrawal, repair, or replacement remains materially possible if later events justify it.

The reserve can decay. Complementary investment, personnel turnover, institutional specialization, migration of data, loss of alternative providers, dependency formation, and legal or technical lock-in can make an intervention progressively harder to reverse. Monitoring reversibility therefore belongs inside the intervention lifecycle rather than being postponed until exit becomes necessary.

Proposition 11.459 (Reversibility preservation). *Where a consequential intervention derives part of its practical warrant from the possibility of later correction, its governance should preserve and periodically reassess the authority, capability, memory, alternatives, and affected-position protections required for meaningful rollback or exit as long as those possibilities remain decision-relevant.*

11.25.4 Partial Reversal

Many interventions can be reversed only in part. Some technical components can be removed while institutional categories persist. Funding can cease while expectations and dependencies remain. A rule can be formally repealed while records, incentives, or precedents continue to shape later practice. Partial reversal should therefore be treated as a normal methodological case rather than an imperfect approximation to complete restoration.

Definition 11.460 (Partial reversal). A *partial reversal* is a rollback operation that materially reduces or reconstructs one or more implemented transformations while other intervention-generated changes, consequences, relations, obligations, or historical residues remain in the practical field.

Definition 11.461 (Reversal frontier). A *reversal frontier* records the boundary between intervention-generated changes that remain feasibly reversible under the present architecture, changes that require repair or substitution rather than direct reversal, and changes that are effectively irreversible within the relevant practical horizon.

The reversal frontier can move. An early intervention stage can be highly reversible; later complementary investments can move components across the frontier. New technology, institutional reform, or restored capability can sometimes move a previously irreversible component back toward practical recoverability. The frontier should therefore be versioned rather than treated as fixed at design time.

Partial reversal can be selective in depth. An institution can retain beneficial capacities generated by the intervention while removing a harmful rule. A representation regime can preserve a useful dataset while abandoning a stigmatizing classification. A relational arrangement can retain coordination while redistributing authority. The objective is not necessarily to approximate the exact pre-intervention state, but to re-

construct a more supportable configuration while explicitly recording what remains.

The repair remainder developed in Section 11.24 is central here. A partial reversal should produce a *reversal remainder* identifying irreversible effects, unresolved claims, residual dependencies, foreclosed options, and consequences whose attribution remains uncertain. This prevents a successful technical rollback from being narrated as complete restoration where the historical field remains transformed.

Definition 11.462 (Reversal remainder). A *reversal remainder* is the set of materially relevant intervention-generated effects, obligations, uncertainties, relational changes, capability changes, and historical residues that persist after the feasible rollback or restoration operation has been completed.

11.25.5 Orderly Withdrawal

Withdrawal concerns the cessation or transfer of continuing practical involvement. Its quality depends on the transition architecture between active support and the post-withdrawal field. Abrupt withdrawal can convert a previously manageable intervention into a capability, maintenance, or responsibility failure. An orderly withdrawal therefore treats handoff, continuity, protection, and memory as part of exit rather than as optional administrative closure tasks.

Definition 11.463 (Orderly withdrawal pathway). An *orderly withdrawal pathway* is an event-ordered transition through which active intervention, support, operation, authority, or participation is reduced or transferred while specified protections, capability handoffs, information continuity, responsibility transfers, repair obligations, and post-withdrawal observation remain sufficiently preserved.

The pathway can contain events such as notification, consultation, transfer of records, capability development, authorization of a successor, testing of fallback arrangements, transfer of assets or maintenance responsibility, final operational withdrawal, and post-withdrawal review. Their order should reflect actual dependencies. Capability handoff may need to precede termination of technical support; responsibility acceptance may need to precede transfer of operational authority; affected-subject notification can need to precede data migration or service closure.

The event structure can remain partially ordered. Several transfers can occur concurrently. Some observation events can continue after operational withdrawal. A successor institution can begin adaptation before the exiting actor fully leaves. The method should represent these relations without imposing a total sequence where none is required.

Withdrawal should also distinguish *transfer* from *abandonment*. Transferring responsibility is not achieved by merely naming a successor. The successor must possess or acquire sufficient authority, capability, resources, information, and practical opportunity to assume the role. A nominal transfer that leaves these conversion conditions absent can create a responsibility gap while allowing the exiting actor to describe the transition as complete.

Definition 11.464 (Withdrawal handoff record). A *withdrawal handoff record* documents the responsibilities, assets, capabilities, information, records, authority, dependencies, unresolved risks, affected positions, receiving subjects or institutions, accep-

tance conditions, predecessor events, and residual obligations associated with the transition out of active involvement.

Orderly withdrawal can also require deliberate reduction of dependence before exit. If the intervention has generated a relation in which affected subjects cannot sustain the relevant function independently, the exit architecture can include capability transfer, diversification, redundancy, or alternative access as predecessor conditions. This is especially important where the intervention itself created the dependence.

11.25.6 Residual Obligations

Operational exit does not necessarily terminate responsibility. Earlier action can generate obligations that persist after funding, authority, implementation, or participation ends. These obligations can concern repair, compensation, maintenance, data, information, records, capability, environmental restoration, accountability, or long-horizon monitoring.

Definition 11.465 (Residual obligation). A *residual obligation* is a responsibility generated or preserved by an earlier practical relation or intervention history that remains materially relevant after operational exit, withdrawal, rollback, transfer, or formal project closure.

Residual obligations should be linked to the history that generated them. They are not simply indefinite moral claims attached to every past intervention. A maintenance obligation can follow from infrastructure introduced by the intervention. A compensation obligation can follow from realized harm. A data obligation can follow from information collected under an earlier observation regime. A memory obligation can follow from risks that later actors need to understand. The practical relation between earlier action and later responsibility should remain traceable.

Definition 11.466 (Residual-obligation ledger). A *residual-obligation ledger* records each surviving obligation, its historical basis, responsible position, affected positions, required action or resource, temporal or event-order condition, transferability, monitoring requirement, completion criterion, and unresolved uncertainty or contestation.

Transfer of an obligation should preserve both capacity and accountability. A departing actor can finance a successor's maintenance responsibility, transfer records, retain liability for specified harms, or share responsibility during a transition period. The architecture can therefore contain layered responsibility rather than forcing a single post-exit owner immediately.

Some obligations may persist without a determinate completion date because their object is event-conditioned. Monitoring can continue until a delayed consequence becomes sufficiently resolved; data stewardship can persist until lawful deletion, transfer, or archival conditions are met; repair can remain open until an affected capability is restored or an explicitly preserved remainder is acknowledged. Event-order conditions can therefore be more appropriate than arbitrary calendar endpoints.

Proposition 11.467 (Residual-responsibility continuity). *Exit is responsibility-preserving insofar as obligations generated by the intervention history remain traceable to capable and accountable positions until they are discharged, legitimately*

transferred, transformed into another responsibility, or preserved as an explicitly unresolved residual claim.

11.25.7 Residual Relational and Historical Effects

Exit changes the field but does not remove the historical fact that the intervention occurred. Relations, expectations, categories, infrastructures, knowledge, habits, obligations, and action-space changes can continue after active involvement ends. Evaluation should therefore distinguish the end of the focal intervention from the end of its generative consequences.

Definition 11.468 (Post-exit relational-historical profile). A *post-exit relational-historical profile* records materially relevant relations, institutional arrangements, subject transformations, representations, dependencies, capacities, constraints, expectations, action-space changes, history-space changes, and unresolved claims that persist after operational exit or rollback.

Residual effects can be beneficial, harmful, or mixed. A pilot can leave useful institutional memory after closure. A withdrawn service can leave trained staff and durable coordination. A failed classification system can leave stigmatizing categories in records. A temporary intervention can create expectations that alter later legitimacy. The methodology should preserve this heterogeneity rather than assuming that residuality is synonymous with damage.

The historical-relational subject architecture is particularly important here. Subjects who participated in the intervention can carry new capabilities, classifications, memories, expectations, or institutional relations after exit. In a partially ordered or 2-complex representation, the exit event becomes one event in the subject's continuing history rather than a deletion of the earlier vertices and relations. Later action therefore begins from an historically transformed subject.

Exit can also alter the action space of actors who remain. The departure of one institution can foreclose coordination options, free resources, generate local autonomy, or create new dependencies. These changes belong to the exit consequence structure even where the exiting actor is no longer operationally present.

Definition 11.469 (Exit consequence remainder). An *exit consequence remainder* records the materially relevant post-exit effects that remain unresolved, difficult to attribute, effectively irreversible, or not yet representable within the dominant evaluation architecture.

Preserving the remainder protects against an administrative fiction in which closure documentation erases the continuing historical field. It also creates an evidential basis for later post-exit monitoring, institutional learning, responsibility review, or re-entry.

11.25.8 Post-Exit Monitoring

Post-exit monitoring extends observation beyond the end of active intervention where delayed, redistributed, residual, or uncertain consequences remain practically relevant. Its purpose is not to maintain indefinite control over the field, but to preserve enough epistemic access to discharge residual responsibilities, detect

delayed harm, evaluate rollback, and determine whether further repair, re-entry, or responsibility transfer becomes necessary.

Definition 11.470 (Post-exit monitoring regime). A *post-exit monitoring regime* is a bounded observation architecture maintained after withdrawal, rollback, transfer, or termination in order to observe specified residual obligations, delayed effects, relational or historical consequences, rollback performance, and conditions for discharge, repair, re-entry, or renewed inquiry.

The regime should inherit the proportionality discipline of Section 11.21. Monitoring after exit can impose surveillance, reporting burden, dependency, or continued institutional influence precisely when the purpose of exit was to reduce intervention. The observation architecture should therefore identify why each monitored object remains decision-relevant, who bears the burden, who receives the information, and when the observation relation itself should end.

Post-exit observation can remain event-triggered. A review can occur after a successor assumes responsibility, after a rollback stage is completed, when an early-warning event appears, when a delayed effect becomes observable, or when an affected subject invokes a contestability pathway. Uniform periodic monitoring is only one possible implementation.

Monitoring results can generate new epistemic events. Evidence of persistent harm can reopen repair or compensation. Evidence that a transfer failed can reactivate transition support. Discovery of an unanticipated beneficial capacity can alter the interpretation of the exit history. A new representation can reveal that the earlier rollback targeted the wrong mechanism. Post-exit monitoring should therefore preserve the same typed distinction between readout, interpretation, institutional uptake, and practical transformation developed earlier in the chapter.

Definition 11.471 (Post-exit discharge condition). A *post-exit discharge condition* is a specified event or practical state under which a residual monitoring, maintenance, repair, data, or responsibility obligation can be closed, transferred, or reduced because the relevant protected condition, uncertainty, or consequence has become sufficiently resolved.

A discharge condition prevents post-exit governance from becoming indefinite by default while preserving the possibility that some responsibilities legitimately continue until an event rather than a fixed date occurs.

11.25.9 Re-Entry

Re-entry concerns renewed practical involvement after an earlier exit, withdrawal, transfer, or rollback. It should not be represented as return to the original intervention state because the field, subjects, institutions, action space, and knowledge architecture can all have changed during the intervening history. Re-entry is therefore a new practical commitment with historical continuity, rather than restoration of an erased past.

Definition 11.472 (Re-entry condition). A *re-entry condition* is a specified or newly recognized development under which renewed participation, support, authority, operation, or intervention by a previously exited actor or arrangement becomes suffi-

ciently relevant and supportable to require practical consideration.

Possible re-entry conditions include failure of a successor arrangement, newly realized residual harm, emergence of a capability that makes a previously unsafe intervention supportable, renewed request from affected subjects, a new mandate, transformed institutional conditions, or an epistemic event that substantially changes the interpretation of the earlier exit. Re-entry can also occur for repair or knowledge purposes without restoring the original intervention.

Definition 11.473 (Re-entry dossier). A *re-entry dossier* links the earlier intervention and exit history to the present practical configuration, documenting what has changed in subjects, relations, institutions, action spaces, evidence, values, authority, capabilities, obligations, residual effects, and the proposed scope and conditions of renewed involvement.

The event-order architecture is essential. The earlier intervention, exit, residual-history events, and re-entry are connected through one historical structure. Re-entry therefore inherits the consequences of the earlier branch. It cannot assume that the former action space, legitimacy, trust, or capability can be restored merely by reinstating an earlier policy or institution.

Re-entry also requires attention to power and dependence. A system in which an actor repeatedly exits and re-enters can prevent local capability formation or create strategic dependency. Conversely, a protected re-entry pathway can increase safety by allowing temporary withdrawal without forcing irreversible abandonment. Whether re-entry is generative or dependency-producing depends on the relations and capacities that the architecture creates.

Proposition 11.474 (Exit–re-entry continuity). *Re-entry is methodologically adequate insofar as it is evaluated as a new commitment in a historically transformed field, preserves the provenance and residual obligations of the earlier intervention and exit, reconstructs current subjects, institutions, evidence, and action spaces, and establishes fresh conditions for authority, monitoring, revision, rollback, and future exit.*

The exit and rollback methodology developed in this section completes the chapter's treatment of intervention lifecycle governance. Diagnosis, decision, design, experiment, monitoring, evaluation, failure response, repair, rollback, exit, and re-entry now form a connected event-ordered architecture. The next section turns to AI-assisted decision support. Its task is to examine how machine-generated representations, recommendations, simulations, and epistemic events can participate in this architecture while preserving human responsibility, model plurality, traceability, contestability, and the possibility of revision or withdrawal.

11.26 Selected Boundaries of Evidence-to-Decision Systems

The role of this section is to identify several conditions under which a formally specified evidence-to-decision system can remain practically incomplete even when its data, models, optimization procedures, and computational implementation are internally coherent. Its objective is neither to reject formal decision support nor to

reserve final judgment to an undefined residual intuition. It develops six illustrative and recurring boundary conditions that can require practical judgment, institutional responsibility, historical interpretation, human-relational attention, or recursive revision beyond the formal mapping from evidence to recommended action. The six are examples selected because they recur in the present chapter; they are not proposed as an exhaustive taxonomy of the limits of formal decision systems. Other domains and future methodological developments may disclose additional boundary conditions. The discussion proceeds through evidential–normative underdetermination, responsibility retention, human-relational distance, temporal and historical transport, regime-sensitive reliability near critical transitions, and reflexive or performative feedback. The method is meta-methodological. AI-assisted systems, statistical models, optimization pipelines, scoring systems, simulations, and other formal decision infrastructures appear as possible instances of the broader architecture rather than as the section’s primary substantive object.

A formal evidence-to-decision system can be highly useful. It can assemble heterogeneous data, generate forecasts, estimate causal effects, compare scenarios, optimize a specified objective, search large design spaces, and apply decision rules consistently. Its practical authority nevertheless depends on relations that formal closure can leave outside the model: how a goal acquired standing, who bears responsibility for consequences, which aspects of a subject survive representation, whether evidence still transports across historical change, whether the response regime remains stable, and whether deploying the system changes the field it observes.

Definition 11.475 (Formal evidence-to-decision system). *A formal evidence-to-decision system* is a specified arrangement through which represented evidence is transformed by one or more formal, statistical, computational, rule-based, or model-mediated procedures into a decision-relevant ranking, recommendation, classification, trigger, action proposal, or automated action.

Definition 11.476 (Formal decision closure). *Formal decision closure* is the condition in which the represented evidence, evaluative rules, model structure, and decision procedure are treated as sufficient to determine practical commitment within the scope claimed for the system.

Formal decision closure can be appropriate for tightly bounded tasks whose goals, constraints, authority, and response structure are stable enough for the intended purpose. The boundary conditions developed below concern cases in which one or more of those relations remain materially open. They therefore qualify the scope of formal closure without implying that formal methods lack practical value.

Table 11.26 summarizes the six boundary conditions. The retained label reflects the historical development of the chapter source; the table itself now concerns formal evidence-to-decision systems generally.

The six conditions in Table 11.26 can overlap and should be read as a partial map rather than a completed list. A machine-mediated classification can compress a subject, redistribute responsibility, alter eligibility, and generate a new data distribution simultaneously. A policy model can rely on historically transported evidence while the public release of its forecast changes expectations. The purpose of the taxonomy is analytical separation, not the claim that practical failures arise one at a time.

Table 11.26: Six illustrative boundary conditions of formal evidence-to-decision systems.

Boundary condition	Practical remainder outside formal closure	Methodological implication
Evidential–normative underdetermination	Evidence can inform consequences without independently establishing which ends, rights, risks, or distributions should govern commitment	Preserve normative provenance and distinguish inference from practical authorization
Responsibility retention	Models and delegated systems can contribute to action without themselves bearing institutional or moral responsibility	Maintain identifiable duties of authorization, verification, monitoring, repair, and consequence management
Human-relational distance	Formal representations can compress lived history, recognition, meaning, agency, and relational position into administratively tractable proxies	Preserve affected-subject access, interpretive remainder, contestability, and proportionate human judgment
Temporal and historical transport	Evidence generated under one configuration can lose applicability after institutional, technological, relational, or population change	Time-stamp validity claims and re-open transport assumptions when the field changes
Regime-sensitive reliability	Stable-regime models can lose practical reliability near a qualitative transition or under model uncertainty about such a transition	Couple formal output to transition-sensitive monitoring, model plurality, and staged commitment
Reflexive / performative feedback	Use of a classification, forecast, score, recommendation, or rule can change the field that later generates evidence	Treat deployment as part of the history and revise models after consequential uptake

11.26.1 Evidential–Normative Underdetermination

Evidence can constrain practical belief without independently determining practical ends. A model can estimate expected outcomes, causal effects, risks, distributions, or transition probabilities. The move from those estimates to action also requires judgments about which outcomes matter, how risks are distributed, which rights or protections constrain action, whose claims possess standing, which temporal horizons count, and what kinds of loss remain unacceptable.

This boundary condition corresponds to the familiar structure often described through the distinction between descriptive and normative propositions. The methodological point can be stated without requiring a universal theory of value: an evidential statement concerning what is, has been, or is likely to occur does not

by itself contain the practical rule that selects what ought to be pursued. Formal systems can incorporate normative commitments, but the commitments then enter as assumptions, objective functions, constraints, priorities, labels, or decision rules whose provenance remains a separate object of analysis.

Definition 11.477 (Normative input surface). A *normative input surface* is the set of value judgments, rights, protections, distributional priorities, acceptable-risk judgments, temporal priorities, and practical orientations that enter a formal evidence-to-decision system explicitly or implicitly and thereby condition its recommendations.

A normative input can be democratically authorized, legally mandated, institutionally inherited, professionally justified, negotiated among affected positions, or provisionally adopted for exploration. The formal system can help reveal the consequences of those commitments. It cannot erase the need to explain their standing.

The distinction also prevents technical performance from being mistaken for practical legitimacy. A system can estimate a specified objective with high accuracy while the objective itself remains contested. A formally optimal allocation can remain unacceptable because a protected relation or unrepresented value is omitted. Section 11.3 therefore remains logically prior to formal comparison: evaluative frames are historically situated inputs to decision systems, not outputs produced automatically by evidence.

11.26.2 Responsibility Distribution and Retention

Formal and machine-mediated decision systems distribute practical agency across designers, data producers, model developers, institutional owners, operators, reviewers, affected subjects, and authorizing bodies. This distribution can improve specialization and consistency. It can also make responsibility difficult to locate when each participant controls only one part of the decision chain.

Definition 11.478 (Responsibility vacancy). A *responsibility vacancy* arises when a consequential decision process distributes epistemic, technical, institutional, and operational functions in a way that leaves one or more materially relevant duties of authorization, verification, monitoring, explanation, correction, repair, or consequence management without an identifiable bearer possessing sufficient capacity and authority to discharge them.

The problem is therefore stronger than mere diffusion. Shared responsibility can be legitimate when duties remain identifiable. Vacancy appears when a model is treated as if it bears the responsibility of the institution using it, when a vendor controls a consequential component without access to downstream effects, when operators are instructed to follow recommendations they are not authorized to challenge, or when affected subjects have no institution capable of correcting an error after deployment.

Formal systems can support responsibility through provenance, audit logs, role separation, independent review, escalation rules, and versioning. These devices are useful only when connected to actual authority and capacity. A detailed log without a responsible institution can document failure without creating a route for remedy.

Proposition 11.479 (Responsibility retention). *Delegation of observation, inference,*

simulation, optimization, recommendation, or execution should preserve identifiable responsibility relations proportionate to the consequences of the delegated function, including routes for verification, authorization, correction, and repair where these are materially relevant.

Proposition 11.479 applies to AI systems as one contemporary case, but its scope is wider. Committees, consultants, scoring rules, outsourced analytics, bureaucratic procedures, and automated control systems can generate the same structural problem.

11.26.3 Human-Relational Distance and Representational Compression

Formal decision infrastructures operate through representations. They encode subjects, histories, relations, preferences, capacities, harms, and claims in forms that can be compared or processed. Such compression is often necessary for coordination at scale. The boundary condition arises when the practical authority of the representation exceeds its capacity to preserve aspects of lived and relational reality that are material to the decision.

The term *human-relational distance* is used here instead of assuming a fixed essence of “humanity.” The concern is relational: decision processes can become increasingly separated from the persons, communities, practices, meanings, and histories whose consequences they organize. A subject can appear primarily as a score, eligibility state, predicted risk, feature vector, administrative case, or optimization unit. These representations can be appropriate for some tasks while remaining incomplete for others.

Definition 11.480 (Human-relational distance). *Human-relational distance* is the degree to which the representation, decision pathway, and authority structure of a formal decision system separate consequential judgment from the historically situated meanings, agency, recognition, testimony, relations, and practical experience of the affected subjects relevant to that judgment.

Distance is not automatically harmful. Standardization can reduce arbitrary treatment, make large systems governable, and protect individuals from inconsistent personal judgment. The methodological question concerns fit. A highly compressed representation can be adequate for a routine logistics decision and inadequate for a decision whose consequences depend on historical obligation, dignity, care, identity, trust, or context-specific meaning.

Several safeguards can reduce harmful distance without rejecting formalization. Affected-subject testimony can remain available alongside scores. Explanations can identify which representation drove a decision. Contest routes can permit correction of category mismatch. Human review can be allocated to cases where interpretive remainder is material. Participatory design can influence which variables and outcomes enter the system. Historical-relational subject reconstruction from Sections 11.7 and 11.13 can also preserve structures that a point-like representation suppresses.

The concern is therefore compatible with methodological pluralism. Human judg-

ment is itself fallible, situated, and potentially biased. The meta-framework does not idealize unformalized discretion. It requires a proportionate relation among formal representation, lived and historical access, institutional responsibility, and contestability.

11.26.4 Temporal and Historical Transport of Evidence

Formal decision systems often rely on evidence generated before the decision. Training data, historical outcomes, estimated causal effects, calibrated parameters, institutional records, or expert rules can all encode earlier configurations. Their practical validity depends on whether the relations generating those observations remain sufficiently comparable to the field in which the system is now used.

Definition 11.481 (Temporal evidence mismatch). A *temporal evidence mismatch* occurs when evidence generated under an earlier historical-relational configuration is used to support a current commitment while changes in population, institution, technology, classification, behavior, observation, mechanism, or prior intervention materially weaken the transport of the relevant claim.

Temporal mismatch is broader than statistical drift. The field can change in ways that do not appear immediately in marginal data distributions. Legal categories can be redefined. An institution can alter incentives. A technology can create new capabilities. A public model can change behavior. An earlier intervention can select which cases remain observable. A historical process can shift the meaning of the measured variable itself.

The evidence-transport profile from Section 11.4 provides the general method for recording these conditions. Formal systems add a versioning requirement because data pipelines, model parameters, prompts, retrieval corpora, optimization rules, and software dependencies can change at different times from the field being modeled. A recommendation should therefore be linked to the epistemic and computational state that produced it when later consequences require reconstruction.

Temporal validity can also expire during implementation. A model that justified initiation can become weakly relevant after the intervention changes the field. Monitoring should therefore include assumptions about transportability, not only outcome indicators.

11.26.5 Regime-Sensitive Reliability near Critical Transitions

Formal systems can be reliable within one response regime and fragile near a qualitative transition. A statistical relationship calibrated under relative stability can lose transportability; a local optimization can identify an excellent solution inside a basin that is becoming inaccessible; a causal mechanism can change after institutional reorganization; a simulation can omit the transition mechanism that becomes decisive.

Section 11.11 developed critical-transition uncertainty as a model-relative practical problem. The boundary condition for formal evidence-to-decision systems is therefore specific: evidence and models validated under one regime do not automatically establish reliability when the decision itself can approach, induce, or cross a regime boundary.

Definition 11.482 (Regime-sensitive model authority). *Regime-sensitive model authority* is the degree of practical reliance warranted for a formal model after considering the response regime in which it was validated, uncertainty about the current regime, plausible qualitative transitions, and the consequences of model failure across those regimes.

This concept does not require the analyst to prove that the field is near criticality. It requires model authority to weaken or become more conditional when transition uncertainty becomes materially decision-relevant. The appropriate response can include model plurality, transition-sensitive indicators, stress tests, staged action, preserved options, local validity domains, or greater human and institutional review.

Formal models can also be especially valuable near transition. Dynamical analysis, simulation, network models, and sensitivity analysis can reveal mechanisms invisible to ordinary linear extrapolation. The qualification concerns the interpretation of their authority, not their exclusion.

11.26.6 Reflexive and Performative Feedback

The sixth boundary condition arises when the output of a formal system becomes part of the causal field it represents. A score can change access, a forecast can alter expectations, a recommendation can coordinate actors, a model-based threshold can change institutional behavior, and an automated action can reshape the data distribution used for later learning. The evidence-to-decision system then participates in its own future evidence-generating process.

Definition 11.483 (Decision-system performativity). *Decision-system performativity* is the practical condition in which the production, communication, institutional recognition, or implementation of a formal decision output contributes materially to changes in the relations, behavior, constraints, capacities, classifications, expectations, or observations that later constitute the system's evidential environment.

The recursive structure can be described in ordinary language. A field generates evidence; evidence enters a representation; the representation supports a decision; the decision changes the field; and the changed field generates later evidence. The important methodological point is that the later evidence belongs to a different history. Treating it as an independent sample from the pre-deployment process can conceal the effect of the decision system itself.

Performativity can generate apparent success or apparent failure. A warning model can appear over-pessimistic because actors responded to the warning and prevented the forecast event. A ranking system can appear predictive because institutions allocate resources in ways that reinforce the ranking. A recommendation system can narrow exposure and later learn from the population it helped select. Evaluation should therefore preserve the deployment and uptake history when these feedbacks are plausible.

Proposition 11.484 (Open evidence-to-decision architecture). *A formal evidence-to-decision system can be methodologically stronger when its practical use preserves the boundary conditions relevant to its field. The six conditions developed here—normative provenance, responsibility retention, representational remainder, temporal transport,*

regime sensitivity, and performative feedback—provide an illustrative set. Additional conditions can become relevant in other practical configurations. Relevant boundary conditions can be handled inside, alongside, or around the formal system, while their practical standing remains visible and revisable.

Proposition 11.484 explains why the chapter does not seek a fully closed decision machine. Formal methods can carry substantial parts of diagnosis, inference, simulation, optimization, and recommendation. Practical closure remains a historically situated institutional act whose adequacy depends on relations that can extend beyond formal representation.

AI-assisted decision support now fits naturally within this architecture. AI systems can generate scenarios, forecasts, classifications, summaries, optimization proposals, or recommendations, and can also mediate observation and communication. Their specific technical and epistemic properties should be analyzed where relevant, while the general methodological questions of responsibility, human-relational distance, historical transport, regime sensitivity, and performative uptake already apply at the domain-general level. The substantive economic and political-economic consequences of radical human–AI capability asymmetry remain the work of Chapter 18.

Section 11.27 integrates the chapter’s methodological repertoire after these boundary conditions have been made explicit. The integrated architecture therefore cannot be interpreted as a fixed pipeline that converts evidence into action. It is a configurable and recursive practical system whose components, responsibilities, models, evaluative frames, and reopening conditions can change through history.

11.27 Integrated Intervention Design

This section integrates the methodological components developed across Chapter 11 into a configurable recursive architecture for practical intervention. Its role is synthetic: the objective is to show how diagnosis, practical–epistemic situation mapping, reconstruction of historical-relational subjects, situated practical orientation, epistemic conditions, methodological composition, generative history construction, decision, intervention, monitoring, evaluation, model revision, action-space revision, and exit can be related without converting their relations into a mandatory universal workflow. The discussion uses one structural organization to expose interfaces, reopening conditions, and provenance requirements while allowing projects to omit, combine, reorder, deepen, or replace components according to their field and commitment profile. The resulting architecture is a domain-general coordination framework and an open methodological proposal that can later be instantiated in economic praxis.

Definition 11.485 (Integrated intervention architecture). *An integrated intervention architecture is a versioned practical design that connects the subset of diagnosis, practical–epistemic situation mapping, historical-relational subject reconstruction, situated practical orientations, evaluative frames, epistemic conditions, methodological composition, generative history spaces, decision procedures, intervention mechanisms, monitoring, evaluation, representation revision, action-space revision, and exit or rollback conditions that are materially relevant to a particular*

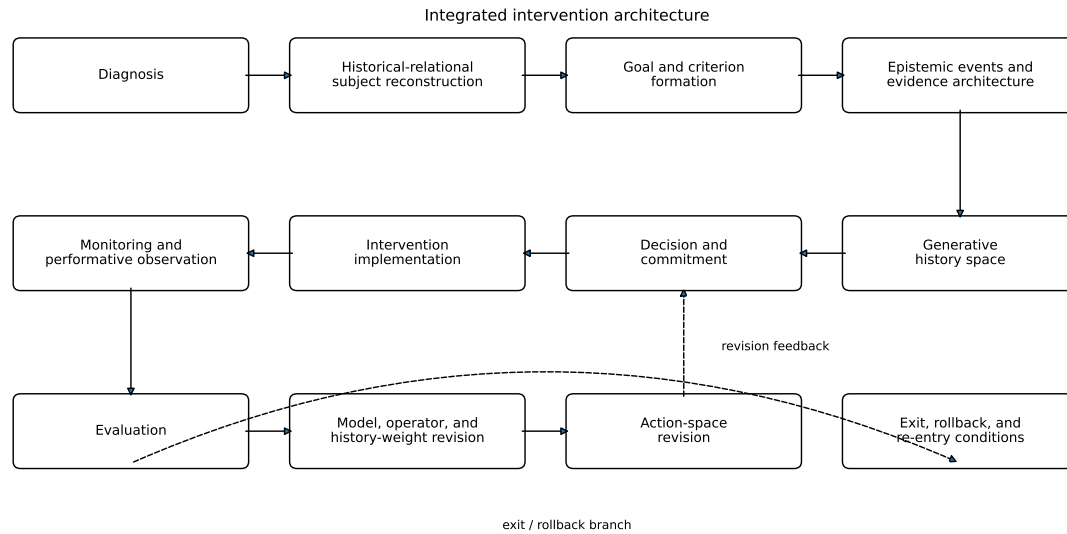


Figure 11.1: One configurable representation of integrated intervention design. The forward path depicts a common coordination route from diagnosis toward implementation and evaluation; the dashed paths show selected routes for reopening commitment or entering exit and rollback procedures. Projects can omit, combine, reorder, or deepen components according to the practical field. The diagram serves a methodological purpose while leaving ontology suspended.

commitment through explicit responsibility, provenance, and reopening relations.

Integration therefore concerns explicit relations among selected practical objects, not completion of a fixed sequence. A small reversible intervention can use a compact architecture, while a deep institutional intervention can require multiple interacting models, participatory structures, staged authorization, independent monitoring, and long post-exit obligations. A revised diagnosis can reopen the evaluative frame; a new epistemic event can alter the estimated history space; a failure signal can change the action set; a model revision can invalidate a recommendation; and an exit event can create residual obligations that become part of a later diagnosis. Other projects can organize these relations differently when their practical history warrants a different order.

Figure 11.1 presents one possible coordination architecture as a recursive cycle. The forward path depicts a common movement from practical reconstruction toward commitment and implementation; it is illustrative rather than mandatory. The return paths represent the possibility that monitoring, evaluation, model revision, action-space revision, or post-exit consequences change the practical situation itself. The figure therefore visualizes one way to coordinate coupled epistemic and practical events while the text preserves alternative orderings and project-specific omissions.

A useful way to preserve this architecture across revision is to treat the current practical design as a versioned state. Let D_k denote the documented intervention-design state at revision step k , let E_k denote newly admitted evidence and epistemic events, let O_k denote observations generated during implementation, and let C_k denote relevant changes in constraints, capacities, relations, institutions, or external conditions. The update relation is stated in Equation 11.55.

$$D_{k+1} = \mathcal{U}(D_k, E_k, O_k, C_k), \quad (11.55)$$

where $\mathcal{U}$ denotes the documented revision procedure appropriate to the project. Equation 11.55 is a project-level bookkeeping formalization with locally specified semantics. Its purpose is to make explicit that the intervention architecture itself is one of the objects that can evolve. The contents of D_k can include qualitative interpretations, participatory records, formal models, institutional rules, legal constraints, model versions, alternative histories, and responsibility assignments. Different projects can therefore instantiate the update procedure through different methodological traditions.

Proposition 11.486 (Integrated traceability). *An intervention design becomes more methodologically accountable when materially consequential changes in diagnosis, goals, evidence, model assumptions, action spaces, implementation, or exit conditions can be traced to the events and judgments that produced the corresponding design revision.*

The remainder of the section develops each component of this architecture and specifies its principal interfaces with the others.

11.27.1 Diagnosis

Diagnosis supplies the initial practical reconstruction on which the rest of the intervention architecture depends. Section 11.2 developed practical diagnosis as a structured inquiry into conditions, relations, constraints, capacities, asymmetries, uncertainties, and possible mechanisms. Within integrated design, diagnosis acquires an additional role: it becomes the first versioned object against which later changes can be interpreted. A project should therefore record both what is believed about the practical field and how that belief was produced.

Definition 11.487 (Integrated diagnostic state). *An integrated diagnostic state is a versioned reconstruction of the practical field that records the focal condition, relevant relations, constraints, capacities, asymmetries, historical processes, uncertainties, observation gaps, candidate mechanisms, affected positions, and the evidence and interpretive procedures supporting those elements.*

The diagnostic state should distinguish at least three kinds of uncertainty. The first concerns incomplete observation: relevant events, relations, or positions can remain poorly observed. The second concerns interpretive uncertainty: the same records can support multiple historical or causal reconstructions. The third concerns practical uncertainty: even a well-described field can respond unpredictably to intervention because the intervention changes relations, expectations, incentives, classifications, or capacities. Keeping these uncertainties distinct helps determine whether the appropriate next action is additional observation, comparative interpretation, formal modeling, a pilot intervention, participatory inquiry, or deliberate preservation of flexibility.

Diagnosis also requires a boundary decision. The practical field can rarely be represented exhaustively. Integrated design should therefore identify which relations, scales, histories, and neighboring systems are treated as internal to the current anal-

ysis and which are represented as external conditions. Boundary choices should be revisable because intervention can create new dependencies. A local program can become institutionally coupled to a wider funding regime; a technological intervention can create infrastructural dependence; a classification can change who is administratively recognized as a member of the target population.

The diagnostic state should contain an uncertainty and omission register. An omission is methodologically different from a finding of absence. If a group, relation, or historical process is weakly represented because the observation system does not capture it, the integrated design should preserve that limitation. Subsequent model outputs, scenario families, or recommendations can then preserve the weakly observed status of the omitted material explicitly.

Diagnosis also establishes the practical baseline for later evaluation, yet the baseline itself can be transformed by the intervention. This point is especially important where public announcement, eligibility criteria, monitoring systems, or anticipatory behavior begin before formal implementation. The relevant pre-intervention history should therefore include preparatory epistemic and institutional events when those events can influence later outcomes.

Caution 11.488 (Diagnostic closure). A diagnosis can become practically misleading when it is treated as a fixed description after the intervention, monitoring regime, or surrounding conditions have changed the field. Integrated design should preserve explicit triggers for reopening the diagnostic state.

Reopening triggers can include contradictory evidence, emergence of a previously unobserved affected position, failure of a key mechanism, a structural break, model drift, a change in institutional authority, a new legal or material constraint, or persistent divergence between observed and expected histories. Reopening diagnosis is therefore part of competent intervention design, not evidence that the initial inquiry was methodologically pointless.

11.27.2 Historical-Relational Subject Reconstruction

Historical-relational subject reconstruction identifies who or what occupies practically relevant positions within the evolving field. Section 11.7 developed the historical-relational decision subject as a subject represented through its event history, relations, capacities, classifications, and transformations. Integrated intervention design extends that idea from decision analysis to the complete intervention lifecycle.

Definition 11.489 (Integrated subject reconstruction). An *integrated subject reconstruction* is a versioned representation of a practically relevant subject or subject-position that links identity conditions, event history, relations, capacities, constraints, classifications, institutional locations, exposure to intervention, available responses, and transformation pathways to the decisions and evidence that depend on that representation.

The reconstruction can concern persons, households, organizations, communities, institutions, ecological actors, infrastructures, or other entities appropriate to the application domain. GR does not require that these objects share one ontological sta-

tus. The methodological requirement is that their practical role be represented with enough historical and relational structure to avoid collapsing a trajectory into a static label when the trajectory matters for action.

Subject boundaries should remain explicit. A person can participate in several institutional and relational positions simultaneously. An organization can have internal subgroups with divergent capacities and exposures. A community can change composition during the intervention. A platform or administrative system can mediate the actions available to subjects and therefore function as part of the practical subject architecture. Integrated design should document which level of subject reconstruction supports each claim and decision.

Historical-relational reconstruction is especially important for intervention sequencing. Two subjects with similar current measurements can possess different prior event histories and therefore different capacities, obligations, trust relations, vulnerabilities, or responses to the same intervention. A prior classification can influence eligibility; a previous failed intervention can alter willingness to participate; accumulated institutional dependence can make nominally reversible change practically difficult. The intervention architecture should therefore avoid treating current-state equivalence as sufficient evidence of trajectory equivalence.

The subject reconstruction should also record intervention-generated transformation. Once a program changes a subject's recognized status, resource access, relationships, obligations, expectations, or institutional location, later decisions should use the transformed reconstruction. This avoids a common methodological error in which the initial target population remains conceptually fixed while the intervention itself changes the subjects and relations under study.

Proposition 11.490 (Subject-state continuity). *When an intervention materially transforms a subject's relations, capacities, classifications, or institutional position, subsequent decision and evaluation stages should reference an updated historical-relational reconstruction while retaining the pre-intervention subject state as historical provenance.*

Participation can contribute directly to subject reconstruction. Affected positions can identify relations, meanings, constraints, and historical events that are weakly visible to institutional data systems. Participatory evidence should therefore enter the reconstruction with its provenance preserved, alongside quantitative, historical, interpretive, administrative, or computational evidence. Integration does not require reduction of these forms to one scale of representation.

11.27.3 Situated Practical Orientation

Situated practical orientation links diagnosis to the evaluative frame through which commitment becomes intelligible. Section 11.3 treated goals and criteria as possible local articulations of historically formed orientations rather than universal inputs. Integrated design therefore records the orientations, protections, obligations, criteria, and comparison rules that materially organize the intervention together with their provenance and revision conditions.

Definition 11.491 (Orientation-integration record). *An orientation-integration*

record documents the practical orientations, any local goals or criteria, protected conditions, relevant values, affected positions, institutional authority, evidential basis, conflicts, comparison rules, uncertainty, and revision conditions that organize an intervention design at a specified stage of its history.

Where explicit objectives are appropriate, an integrated design can distinguish terminal objectives from enabling objectives. A project can seek an ultimate improvement in some practical condition while pursuing intermediate capacities, infrastructures, relationships, knowledge, or institutional arrangements that make later improvement possible. Treating enabling objectives explicitly can prevent early evaluation from misclassifying a capacity-building stage as failure merely because the final outcome has not yet appeared.

Practical orientations and any associated goals can possess different temporal horizons. Immediate protective goals can coexist with medium-term relational goals and long-term generative goals. The architecture should record possible tension among these horizons. An action that rapidly improves an immediate indicator can reduce later adaptability; a slower intervention can increase capacity while leaving short-term burdens insufficiently addressed. Integrated design can therefore use a temporally differentiated orientation architecture when the practical situation contains such tensions.

The evaluative frame should identify protected constraints and obligations separately from dimensions that can legitimately enter trade-off or optimization. Some conditions can function as side constraints on the action space; others can operate as evaluation criteria among feasible alternatives. This distinction should be visible before formal optimization or delegated recommendation because computational systems can otherwise treat a protected condition as merely another weighted term.

Practical orientations, goals, and criteria can change legitimately when the field changes, when affected positions contribute new information, or when intervention-generated evidence reveals an overlooked consequence. Revision should preserve the historical record of the previous goal state. This makes it possible to distinguish success under the original objective from success under a later revised objective and to identify whether a favorable evaluation results from genuine improvement or from retrospective movement of the criterion.

Definition 11.492 (Evaluative-frame reopening trigger). An *evaluative-frame reopening trigger* is a pre-specified or subsequently justified condition that initiates reconsideration of an intervention's orientations, goals, criteria, protected constraints, or comparison structure because the practical field, available evidence, affected positions, institutional mandate, or anticipated consequences have materially changed.

Revision of the evaluative frame can itself be an epistemic and political event. Changing what counts as success, protection, admissibility, or relevant value can redistribute attention, resources, recognition, and burden. Integrated design should therefore identify who has authority to revise the frame, who can contest the revision, and how changes propagate to monitoring indicators, decision criteria, models, and exit conditions.

11.27.4 Epistemic Events and Evidence Architecture

Evidence architecture connects the practical field to the representations used for action. Section 11.4 distinguished observation from epistemic events and showed that recognition, classification, communication, institutional uptake, and related processes can alter the field whose evolution they inform. Integrated design makes this distinction operational across the complete intervention cycle.

Definition 11.493 (Integrated evidence architecture). An *integrated evidence architecture* specifies the sources, observation channels, transformations, classifications, interpretive procedures, models, uncertainty representations, provenance records, update rules, access conditions, and performative-coupling pathways through which information enters and changes an intervention design.

The architecture should identify whether an evidential object is primarily descriptive, inferential, predictive, interpretive, participatory, model-generated, or intervention-generated. These categories can overlap, yet their differences matter for practical use. An administrative record can be strong evidence of an institutional classification while remaining weak evidence of the lived condition that the classification is intended to approximate. A model output can be useful for forecasting while remaining dependent on assumptions whose practical validity is uncertain. A participant account can reveal mechanisms unavailable in aggregate data while requiring careful interpretation of scope.

Provenance should extend beyond source citation. For an operational intervention, relevant provenance can include when the evidence was produced, which version of an observation system generated it, how missingness was handled, which transformations were applied, which model or interpretive frame mediated it, who authorized its use, and which decisions subsequently relied on it. This is especially important when later evaluation asks whether an intervention failed because the mechanism was inadequate or because the evidence architecture systematically misrepresented the field.

Performative coupling requires a separate record. Publishing a risk classification can change behavior; communicating a forecast can influence expectations; introducing a monitoring system can alter reporting; an AI recommendation can become a coordination signal; eligibility criteria can change how subjects present themselves. These effects should enter the design as possible causal pathways within the intervention field.

Definition 11.494 (Epistemic-event ledger). An *epistemic-event ledger* records materially relevant acts of observation, classification, recognition, interpretation, communication, model output, institutional uptake, contestation, and revision together with their provenance, intended epistemic function, possible performative effects, and links to subsequent practical decisions.

The ledger can remain qualitative. Its purpose is historical traceability. Section 11.4 provides the conceptual distinction between epistemic content and practical uptake, while Section 11.12 provides optional operator, field, history, and transition representations when formalization is useful. Any formal representation should preserve the distinction between a computational object and the empirical or institutional process it represents.

Formal and machine-mediated observation or recommendation belong inside this epistemic architecture when their outputs materially affect action. Section 11.26 identifies boundary conditions concerning normative provenance, responsibility, human-relational distance, temporal transport, regime sensitivity, and performative feedback. Integrated design should record the model or rule version, source evidence, mediation chain, uncertainty, responsible roles, contest routes, and later uptake at a depth proportionate to practical consequence.

11.27.5 Generative History Space

Generative history construction links the reconstructed present to possible later developments. Sections 11.8 and 11.12 developed scenario families, alternative histories, formal models, history complexes, and history weights. Integrated design organizes these resources around the decisions and interventions that can change which histories remain accessible.

Definition 11.495 (Integrated generative history space). An *integrated generative history space* is a documented family of relevant possible histories generated from the current diagnostic, subject, relational, institutional, and evidential state, with explicit assumptions concerning transition conditions, action dependence, uncertainty, performative epistemic effects, and the criteria by which histories are compared or revised.

A history space can be represented narratively, comparatively, through causal models, simulation, event graphs, partially ordered complexes, stochastic processes, dynamical systems, or combinations of these methods. Integrated design selects the representation according to the practical question. The architecture should resist conversion of methodological plurality into a single formal vocabulary when the conversion would discard relevant meaning or uncertainty.

The central object is the family of plausible or decision-relevant developments, not a claim that the future is fully enumerable. Some interventions are characterized by deep uncertainty in which important future states, mechanisms, or criteria remain partially unknown. In such cases, the history space should include unknown-region markers, stress scenarios, qualitative boundary cases, and conditions for expanding the action space when surprises arise.

History construction should include the intervention's epistemic effects. If publishing an evaluation changes participation, or if a model-mediated classification changes institutional treatment, then those epistemic events belong inside the possible histories. Similarly, observation can be endogenous to intervention because monitoring changes visibility, classification, and response. The history space therefore links practical and epistemic evolution.

The architecture should distinguish transition plausibility from value. A history can be plausible and undesirable; desirable and weakly supported; robustly acceptable across several models; or strongly dependent on one contested assumption. Keeping these dimensions distinct allows decision analysis to compare practical support without treating probability, preference, and legitimacy as interchangeable quantities.

Definition 11.496 (History-space revision trigger). A *history-space revision trigger* is an event or evidential condition indicating that the currently represented family of possible histories has become materially incomplete, misweighted, structurally mis-specified, or practically outdated for the decision at hand.

Examples include observation of a transition absent from the model, emergence of a new actor or constraint, failure of a central mechanism, a structural break, persistent residual error, reinterpretation of a historical analogy, successful contestation of a classification, or intervention-generated transformation of the subject population. Revision should preserve the previous history space and the event that motivated replacement or expansion.

11.27.6 Decision

Decision transforms reconstructed possibilities into practical commitment. Sections 11.7–11.14 developed action spaces, robustness, adaptive decision-making, optimization, formal and quantitative models, historical interpretation, and participatory methods. Integrated design coordinates these resources through an explicit decision dossier that connects the choice to the current versions of diagnosis, goals, evidence, subject reconstruction, and history space.

Definition 11.497 (Integrated decision dossier). An *integrated decision dossier* records the decision situation, admissible action space, goals and protected conditions, affected positions, relevant histories, comparison methods, uncertainties, robustness and sensitivity results where applicable, participatory or institutional judgments, dissent, authorization, implementation conditions, monitoring obligations, revision triggers, and exit or rollback provisions associated with a practical commitment.

The action space should be treated as constructed. Institutional rules, material constraints, available knowledge, imagination, social legitimacy, technology, and prior decisions determine which actions are visible and feasible. A decision process that compares only currently recognized alternatives can therefore reproduce an artificially narrow possibility space. Integrated design should preserve mechanisms for action generation, including participatory proposals, redesign of institutional constraints, staged capability building, and machine-assisted exploration where appropriate.

Decision criteria should remain linked to their provenance. Robustness analysis can identify actions that perform acceptably across model or scenario uncertainty. Optimization can help when objectives, constraints, and relevant quantities are sufficiently specified. Historical and interpretive analysis can identify meanings or path dependencies unavailable to a compact numerical model. Participatory methods can reveal affected positions and legitimate criteria. An integrated decision does not require these methods to produce one common metric. It requires a documented relation among their contributions.

Decision authority should be distinguished from epistemic contribution. A model can supply a forecast; an affected group can supply experiential evidence; an expert can evaluate mechanism plausibility; an institution can hold legal authority; a deliberative body can establish a value-sensitive criterion. Collapsing these roles into a

single hierarchy can conceal where practical responsibility actually lies. The dossier should therefore state who contributes what kind of judgment and who ultimately authorizes commitment.

Proposition 11.498 (Decision–design correspondence). *A practical commitment is more traceable when the selected action can be mapped to the current diagnostic state, subject reconstruction, goal-formation record, evidence architecture, history space, comparison procedure, and authorization process that jointly support it.*

Conditional decisions can be especially valuable under uncertainty. A staged decision can specify an initial action together with observation conditions and later branches. This converts part of the decision problem into a designed learning process. The value of such staging depends on whether the initial stage preserves meaningful future options and whether monitoring can generate information before irreversible commitments accumulate.

11.27.7 Intervention

Intervention is the realized modification of the practical field. Sections 11.15–11.20 developed target selection, timing, scale, depth, mechanism design, pilots, and experimental intervention. Integrated design binds these dimensions into a versioned implementation architecture whose realized form can be compared with the intervention that was authorized.

Definition 11.499 (Integrated implementation state). *An integrated implementation state records the intervention actually enacted at a specified stage, including targets, mechanisms, timing, sequence, scale, depth, responsible positions, resources, enabling conditions, constraints, protective measures, deviations from design, generated epistemic events, and the links between implementation actions and the decision dossier that authorized them.*

The distinction between designed and realized intervention is essential. Implementation can diverge because resources arrive late, institutions adapt procedures, affected subjects respond unexpectedly, personnel exercise discretion, technical systems change, or external events alter feasibility. Evaluation should therefore compare outcomes with the intervention actually realized and preserve the original plan as a separate reference object.

Target, timing, scale, and depth should be recorded together because their interactions can determine practical effects. A mechanism that works at a pilot scale can encounter coordination constraints at larger scale. A shallow informational intervention can become a deep relational intervention if access to essential resources becomes conditional on compliance. A temporary classification can become historically durable if later institutions reuse it. Integrated design therefore evaluates intervention dimensions through their combined history.

Intervention can create new capacities as well as new constraints. An implementation stage can deliberately construct later action space by building knowledge, infrastructure, relationships, institutions, or participation channels. These generative effects should be recorded even when they are intermediate to the original outcome. Conversely, an intervention can consume reversibility reserves, narrow future op-

tions, or create dependencies. The implementation state should make both directions visible.

Protective measures belong inside intervention design. They can include staged exposure, bounded eligibility rules, independent review, opt-out routes, compensation reserves, alternative service pathways, data-minimization procedures, rollback capacity, or protection of groups bearing concentrated risk. Their adequacy should be evaluated under the same monitoring and revision architecture as the primary mechanism.

Caution 11.500 (Implementation identity). An intervention should not be treated as a stable treatment label when its mechanism, scale, target population, institutional environment, or observation regime has materially changed. Versioned implementation records preserve the distinction among substantively different intervention histories.

11.27.8 Monitoring and Performative Observation

Monitoring creates the principal recursive interface between implementation and revision. Sections 11.21 and 11.22 developed monitoring regimes, relational and generative indicators, observer effects, feedback architecture, and adaptive revision. Integrated design combines these elements by treating monitoring simultaneously as measurement, evidence production, and a possible intervention in its own right.

Definition 11.501 (Integrated monitoring state). An *integrated monitoring state* records the current observation architecture, indicators, source and transformation provenance, reporting cadence, responsible positions, uncertainty, intervention-generated evidence, observer and classification effects, warning conditions, feedback pathways, and the practical revisions that monitoring can trigger.

Indicator selection should follow from the complete intervention architecture. Immediate outcomes can show whether implementation occurred; relational indicators can show how interaction patterns change; capacity indicators can show whether subjects gain or lose practical ability; constraint indicators can reveal newly binding limitations; generative indicators can track changes in future option space; distributional indicators can identify concentrated burdens or benefits. A compact dashboard can be useful only when its compression remains connected to the richer evidence architecture behind it.

Monitoring frequency should match the dynamics and consequences of the intervention. High-frequency observation can be valuable where rapid failure requires immediate protection. It can also impose burden, generate noise, encourage short-horizon optimization, or intensify surveillance. Lower-frequency monitoring can miss rapid transitions. Integrated design therefore links cadence to the temporal structure of the mechanism and to the practical cost of observation.

Performative observation deserves explicit treatment. A published performance score can redirect organizational effort; risk monitoring can change behavior; repeated surveying can influence participants; algorithmic classification can alter access; visible thresholds can induce strategic adaptation. The monitoring state should therefore distinguish changes in the field from changes induced by the monitoring

regime itself where the distinction is practically relevant.

Definition 11.502 (Monitoring-mediated intervention event). A *monitoring-mediated intervention event* occurs when an observation, indicator, classification, report, alert, or feedback communication generated by the monitoring system materially changes relations, behavior, institutional response, resource allocation, or subsequent observability within the intervention field.

Such events should be incorporated into the epistemic-event ledger and the generative history space. They can be beneficial, as when an early-warning signal activates protection, or harmful, as when a public classification stigmatizes a group. Their inclusion prevents the monitoring system from being treated as an external spectator when it participates in the practical dynamics.

Monitoring should also protect negative evidence. Absence of the expected effect, emergence of a contradictory case, and persistent disagreement among evidence sources can be more informative than smooth confirmation of the intervention theory. Integrated design should therefore preserve exception channels that prevent aggregation from erasing diagnostically important cases.

11.27.9 Evaluation

Evaluation interprets the evolving intervention history against goals, criteria, mechanisms, and affected positions. Section 11.23 developed immediate, relational, structural, capacity, constraint, option-space, historical, and generative forms of evaluation. Integrated design organizes these forms into a claim architecture that distinguishes what has been observed from what can be inferred and what remains open.

Definition 11.503 (Integrated evaluation state). An *integrated evaluation state* is a time-indexed set of evaluative claims linking realized implementation, observed outcomes, relational and structural changes, subject transformations, capacity and constraint effects, option-space changes, historical interpretation, uncertainty, affected-position evidence, and the goals and criteria against which those effects are assessed.

Evaluation should remain sensitive to delay. Some effects appear quickly while others require longer histories. A short-term improvement can coexist with a slower erosion of capacity; an intervention that initially increases burden can later generate durable access or coordination; structural effects can remain latent until a later shock reveals them. The evaluation state should therefore specify the temporal horizon of each claim.

Attribution should also be scoped. In complex intervention fields, several processes can contribute to the observed history. Evaluation can estimate causal contribution through experimental, quasi-experimental, comparative, process-tracing, formal, interpretive, or mixed methods where appropriate. The integrated architecture records the inferential basis and its limitations while permitting method choice to follow the local attribution problem.

Evaluation should compare the realized history with several reference objects. These can include the pre-intervention baseline, one or more counterhistories, the expected generative history family, alternative interventions, protected constraints, and trajectories of differently positioned subjects. Comparison against a single aggre-

gate outcome can conceal whether an intervention improved one dimension while generating concentrated harm elsewhere.

Failure detection and repair developed in Section 11.24 enter evaluation through explicit criteria. The project should distinguish poor outcome, mechanism failure, implementation failure, observation failure, criterion failure, model failure, and distributional or ethical failure where these categories are analytically useful. The classification of failure determines which component should be revised.

Proposition 11.504 (Evaluation as revision input). *Within integrated intervention design, evaluation has a practical function when its claims are linked to explicit continuation, repair, model revision, action-space revision, rollback, compensation, or exit pathways appropriate to the type and severity of the finding.*

An evaluation can therefore generate several responses. It can confirm continuation under the current architecture; motivate parameter adjustment; reopen diagnosis; revise the subject reconstruction; change goals; replace a model; expand the action space; initiate repair or compensation; reduce scale or depth; or trigger exit. The appropriate response depends on the provenance and scope of the evaluative claim.

11.27.10 Model, Operator, and History-Weight Revision

Model revision updates the representations through which the intervention architecture anticipates and interprets practical evolution. Sections 11.4, 11.12, and 11.22 developed model plurality, practical operators, history complexes, history weights, sensitivity, model risk, and feedback-driven revision. Integrated design combines these elements by specifying which observations or epistemic events can revise which representational components.

Definition 11.505 (Integrated representation-revision record). *An integrated representation-revision record documents a materially relevant change to a practical model, operator, transition rule, history family, history weight, parameterization, classification system, or interpretive frame together with the evidence, discrepancy, judgment, responsible position, validation procedure, and downstream decisions affected by that change.*

A model revision can take several forms. Parameters can change while structure remains stable. Variables or relations can be added or removed. A transition mechanism can be replaced. A model can be restricted to a smaller validity region. Competing models can receive different practical weight. A qualitative historical interpretation can replace an inadequate quantitative representation for one part of the decision. An entire model family can be retired when the practical field moves beyond its assumptions.

Operator revision concerns representations of events that change the practical field. If a classification event has stronger effects than expected, its operator representation can be revised. If an institutional announcement changes behavior only under certain relational conditions, the operator can be conditioned accordingly. In applications where operator algebra is useful, order effects can be represented explicitly. The formal update remains a model of practical sequencing under the chapter's

ontological-suspension commitment.

History-weight revision concerns the relative practical support assigned to alternative histories under the current evidence and model family. A new observation can increase support for one trajectory, reduce support for another, or reveal a previously omitted branch. Weight revision should preserve the model and evidence dependence of the weights. A numerical weight is meaningful only within the interpretation that generated it.

The architecture should distinguish learning from adaptive overfitting. Frequent revision can improve fit to recent observations while reducing stability, interpretability, or transfer. A project should therefore record revision thresholds, validation procedures, holdout evidence where appropriate, historical plausibility checks, and independent review for changes with large practical consequences.

Caution 11.506 (Revision-induced instability). A practical architecture can become difficult to evaluate when models, criteria, indicators, and implementation rules change faster than their consequences can be observed. Revision cadence should therefore reflect the temporal structure of the effects under study and the risks associated with delayed correction.

Machine-mediated and externally maintained models require the same discipline with additional version dependencies. A provider-side update, retrieval-corpus change, prompt or interface change, tool integration, or model substitution can alter outputs without an obvious change in the surrounding practical field. The boundary conditions in Section 11.26 therefore reinforce the need to link computational versions, responsible institutions, transport assumptions, and consequential uptake to the intervention-design state that relied on them.

11.27.11 Action-Space Revision

Action-space revision converts learning into new practical possibility. Sections 11.7 and 11.22 treated action spaces as evolving and developed pathways through which feedback can add, remove, suspend, sequence, or redesign actions. Integrated design places this process after evaluation and representation revision while allowing it to occur earlier when urgent evidence reveals that the current action set is unsafe or inadequate.

Definition 11.507 (Integrated action-space revision). An *integrated action-space revision* is a documented change to the set, structure, feasibility status, sequencing, authorization conditions, or design parameters of practical actions available to the intervention process, grounded in revised diagnosis, evidence, goals, models, capacities, constraints, or institutional conditions.

Action-space expansion can arise through innovation, capability building, institutional redesign, new partnerships, additional resources, participatory proposal, technological development, or reinterpretation of constraints. Contraction can arise because an action proves harmful, loses legal authority, becomes infeasible, consumes a critical resource, or violates a protected condition. Temporary suspension can preserve an action for later re-evaluation while protecting subjects during uncertainty.

The architecture should distinguish feasible from authorized and desirable. An

action can be technically feasible while institutionally unauthorized; legally available while ethically unacceptable under the project criteria; desirable while currently impossible because enabling capacities are absent. These distinctions help identify whether the appropriate intervention is direct implementation or construction of the conditions that make a later action possible.

Action-space revision can also change the decision question. Discovery of a new intervention mechanism can make previous comparisons obsolete. A failed pilot can reveal that the relevant choice concerns institutional redesign at a different analytical level from parameter adjustment. A successful protective measure can enable experimentation that was previously too risky. Integrated design therefore allows revised action spaces to reopen scenario construction, situated practical orientation, and diagnosis.

Definition 11.508 (Option-preservation profile). An *option-preservation profile* records which future actions remain accessible, become newly accessible, become more costly, require additional enabling conditions, or become practically foreclosed under a proposed action or action-space revision.

Option preservation is especially important under deep uncertainty. A policy can achieve a favorable immediate outcome while consuming institutional trust, fiscal capacity, ecological resilience, data rights, technical independence, or other resources needed for later adaptation. The action-space architecture should therefore represent future practical capacity alongside current performance where such effects are material.

Table 11.27 summarizes the principal stage objects and their most important reopening pathways. The table is a coordination aid with project-specific ordering; projects can combine stages or iterate among them at different temporal scales.

11.27.12 Exit

Exit closes one intervention phase while preserving the histories, obligations, and capacities generated by that phase. Section 11.25 distinguished exit, rollback, partial reversal, residual obligation, post-exit monitoring, discharge, and re-entry. Integrated design positions these elements inside the intervention architecture from the beginning of design.

Definition 11.509 (Integrated exit state). An *integrated exit state* records the reason and authority for exit or rollback, the implementation elements terminated or retained, reversibility and reversal remainders, subject and relational conditions at withdrawal, transferred responsibilities, residual obligations, compensation or repair duties, post-exit monitoring, discharge criteria, preserved evidence, and re-entry conditions.

Exit can result from success, failure, external change, completion of a temporary mandate, replacement by another institution, exhaustion of resources, unacceptable risk, or transformation of the problem itself. These pathways have different implications for evaluation. Successful completion can leave maintenance obligations; failed intervention can require repair and compensation; institutional transfer can preserve the mechanism while changing responsibility; emergency termination can

Table 11.27: Principal objects and reopening pathways in integrated intervention design.

Design component	Principal documented object	Illustrative reopening conditions
Diagnosis	Integrated diagnostic state	Contradictory evidence, structural break, omitted affected position, mechanism failure, changed constraints
Situation mapping	Practical–epistemic situation profile	Changed observability, time pressure, uncertainty structure, regime condition, stakes, reversibility, power, or responsibility configuration
Subject reconstruction	Historical-relational subject reconstruction	New event history, reclassification, changed relation, institutional relocation, intervention-generated transformation
Practical orientation	Orientation and criterion record	Changed mandate, affected-position evidence, newly visible harm, transformed feasibility, value conflict, or revised candidate orientation
Methodological composition	Method-composition record	New evidence mode, model disagreement, revealed blind spot, changed decision horizon, failed transfer, or newly available method
Evidence architecture	Evidence architecture and epistemic-event ledger	Observation-system change, contested classification, new source, performative effect, model-mediated error
History space	Generative history space	Unexpected transition, omitted branch, model failure, new actor, changed mechanism or history weight
Decision	Integrated decision dossier	Instability, new action, criterion change, authority change, deepened uncertainty, failed commitment condition
Intervention	Integrated implementation state	Implementation deviation, changed scale or depth, resource failure, new dependency, protection trigger
Monitoring	Integrated monitoring state	Indicator failure, observer effect, warning signal, data drift, burden, changed observability
Evaluation	Integrated evaluation state	Delayed consequence, distributional divergence, failure reclassification, new counterhistory, revised criterion
Representation revision	Representation-revision record	Persistent residuals, invalid assumption, model drift, new evidence, operator or sequencing mismatch
Action-space revision	Action-space version and option-preservation profile	New capacity, new constraint, discovered mechanism, safety suspension, institutional redesign
Exit and rollback	Exit architecture and residual-obligation ledger	Exit condition, rollback trigger, irreversibility, residual harm, discharge condition, re-entry trigger

prioritize immediate protection while leaving unresolved evidence or implementation questions.

Rollback should be connected to the versioned implementation history. Reversal

of the most recent operational change may leave earlier relational or institutional transformations intact. Data generated by a program can persist; subjects can retain changed expectations; new infrastructure can remain; classifications can continue to circulate; contracts or dependencies can outlive funding. The integrated exit state should therefore identify the practical remainder and treat cessation and restoration as separate conditions.

Residual obligations can extend beyond the organization that originally implemented the intervention. A handoff process should identify which institution, community, contractor, public body, or other position assumes ongoing duties. Where responsibility remains disputed, the dispute itself should be documented as part of the exit state because uncertainty over responsibility can become a source of later harm.

Post-exit monitoring should be proportionate to plausible delayed effects. Some interventions require only confirmation that withdrawal is complete. Others can require longer observation because delayed harms, dependency effects, institutional adaptation, or downstream benefits remain possible. The monitoring regime should specify when obligations can be discharged and what evidence is sufficient for discharge.

Re-entry should be treated as a new decision under historically altered conditions. A previous intervention changes the field, so re-entry should use an updated diagnosis, subject reconstruction, evidence architecture, and history space. The old intervention dossier can remain evidence, yet it should not automatically function as authorization for renewed action.

Proposition 11.510 (Recursive closure). *Exit completes an intervention phase methodologically when the withdrawal or rollback decision, residual obligations, post-exit observation, discharge conditions, and possible re-entry pathways are incorporated into the same provenance architecture that governed diagnosis, decision, implementation, and evaluation.*

Definition 11.511 (Integrated intervention dossier). An *integrated intervention dossier* is the linked record through which the current and prior versions of diagnosis, subject reconstruction, goals, evidence architecture, history space, decision, implementation, monitoring, evaluation, representation revision, action-space revision, and exit conditions can be reconstructed together with their unresolved uncertainties, authorities, responsibilities, and cross-stage dependencies.

The dossier need not be a single document. Depending on the practical setting, it can be distributed across qualitative case records, data systems, model repositories, meeting records, decision logs, legal instruments, monitoring dashboards, and archival materials. Integration concerns the ability to reconstruct materially relevant relations among these records. A project can therefore retain methodological plurality while preserving a common practical lineage.

Several design invariants can help maintain this lineage across methodological variation. The intervention process should be able to identify which design version is currently authorized, which evidence and judgments support it, which uncertainties remain open, which positions possess decision and review responsibility, which observations can reopen commitment, and which exit or residual-obligation conditions

remain active. These invariants describe coordination requirements; substantive answers remain project-specific. They can be implemented differently in a small community project, a public institution, a research intervention, or a computationally intensive decision system.

The depth of integration should remain proportionate to commitment. A bounded and readily reversible intervention can use a concise dossier and simple revision record. A large-scale, long-duration, institutionally deep, or difficult-to-reverse intervention can justify more extensive provenance, independent review, participatory records, model validation, protection architecture, and post-exit monitoring. Proportionality prevents integrated design from becoming documentation for its own sake while retaining stronger safeguards where the practical consequences of error are larger.

Proposition 11.512 (Proportionate integration). *The documentary and review burden of integrated intervention design should increase with the depth, duration, scale, uncertainty, dependence, distributional consequence, and irreversibility of the commitment, while preserving a traceable minimum architecture for diagnosis, authorization, monitoring, revision, and exit.*

11.27.13 Methodological Revision and Emergence

Integrated intervention design should preserve the possibility that the methodological architecture itself becomes inadequate. A field can generate an epistemic object that the existing monitoring system cannot represent, a new form of agency that changes responsibility, an institutional transformation that invalidates earlier categories, or a conflict among methods that cannot be resolved through the current composition. These conditions concern more than parameter updating. They can require revision of the methods through which the practical problem is framed and governed.

The situation map in Section 11.5 and the candidate orientations in Section 11.6 provide one way to make such revisions visible. A change from comparative stability to turbulence can shorten useful decision horizons. A newly recognized power asymmetry can make participation or independent review more important. A formal model can disclose sensitivity that motivates historical reconstruction; participant evidence can reveal a relation that requires a model boundary to change. The methodological repertoire can therefore co-evolve with the practical field.

Methodological emergence should not be romanticized. New methods can introduce opacity, instability, capture, administrative burden, or loss of comparability. A novel method can appear responsive while lacking validation. A rapidly revised procedure can make responsibility difficult to trace. Methodological innovation should therefore remain subject to the same demands of provenance, scope, evidence, responsibility, and evaluation that apply to other practical interventions.

Definition 11.513 (Method-composition record). *A method-composition record documents which methodological families are presently used for which practical functions, the reasons for their selection, their known limits and disagreements, the interfaces through which their outputs are combined, and the conditions under which the composition should be revised.*

The record need not enforce a standardized mixed-method design. Its purpose is to prevent the composition from becoming invisible. A project can rely heavily on a formal model when its validity domain is strong, on historical or naturalistic judgment when contextual recognition is decisive, or on participatory processes when affected-position knowledge and value articulation are central. The composition remains justified by the local practical problem.

Proposition 11.514 (Open methodological integration). *Integrated intervention design remains compatible with GR's open research-programme status when the methods coordinated by the design are treated as a revisable repertoire rather than a completed procedural canon, and when materially consequential changes in that repertoire can themselves be documented, evaluated, and contested.*

Proposition 11.514 leaves a genuine research problem open. The present framework does not yet provide a complete theory for composing formal, interpretive, naturalistic, participatory, experimental, and other methods under simultaneous turbulence, deep uncertainty, high stakes, contested values, and changing power relations. Chapter 11 supplies provisional resources for that problem and treats their future revision as part of the research programme rather than as evidence of methodological failure.

Integrated intervention design therefore ends with a return to the conditions for future inquiry and action. The completed intervention history becomes part of the next diagnostic field; generated capacities and constraints become part of the next action space; classifications and institutional changes become part of later subject reconstruction; and unresolved consequences become evidence for future goals and obligations. The recursive architecture gives Chapter 11 a practical synthesis: application-dominant praxis can be organized as a historically traceable cycle in which knowledge and action co-evolve through versioned decisions, interventions, observations, and revisions. Section 310 uses this integrated architecture to specify the transition from domain-general GR methodology to economic praxis and to identify the additional objects that substantive GRE must introduce.

11.28 Economic Specification of Application-Dominant Praxis

The role of this section is to provide the minimal interface through which the domain-general methodology of Part IV can enter substantive Generative Relational Economics. Its objective is intentionally limited. The section does not predefine the economic subject, relation, resource, institution, value form, or economic field in detail, because those objects are developed systematically in Part V. It instead specifies what changes when the general objects of application-dominant praxis receive an economic interpretation and identifies the small set of domain questions required for a disciplined handoff. The discussion proceeds through domain specification, economic interpretation of general practical objects, economic representations and performative interfaces, and the transition to substantive GRE. The method is meta-level and boundary-preserving: economics is treated as one domain instantiation of broader GR foundations, with explicit interfaces to neighboring disciplines and with

substantive content left open to historical and empirical inquiry.

The preceding sections developed a methodology that can be used in many domains. Diagnosis can concern a legal institution, public-health system, educational environment, ecological field, technological infrastructure, or economic process. Historical-relational subjects, evolving action spaces, critical-transition uncertainty, monitoring, repair, and formal decision support therefore carry no exclusively economic meaning. Economic praxis begins when the practical field is specified in terms of economic relations and consequences at a resolution appropriate to the inquiry.

This transition should remain thin. If Chapter 11 were to supply a complete theory of economic subjects, institutions, resources, and value, Part V would repeat rather than develop the substantive programme. The present section therefore provides only a domain-specification interface.

Table 11.28 identifies questions rather than definitions. Each row can be answered differently in housing, labor, finance, care, knowledge production, ecological transition, public goods, platforms, development, international exchange, or another economic field. The common methodological inheritance supports comparison while the substantive ontology and empirical mechanisms remain open.

11.28.1 Domain Specification

Economic specification begins by delimiting why the practical field is being treated as economically relevant. The boundary can follow production, exchange, allocation, ownership, access, labor, consumption, finance, care, infrastructure, institutional provisioning, value conversion, resource dependence, or another economically significant relation. Several of these can coexist.

Definition 11.515 (Economic domain specification). An *economic domain specification* is a scoped and revisable statement identifying the economic relations, practical consequences, historical boundaries, scales, and interfaces that make a selected field relevant to GRE for the inquiry or intervention at hand.

The specification is analytical rather than jurisdictional. A household can be economically relevant without being reducible to market exchange. A legal category can be part of an economic field when it structures ownership or access. An ecological condition can enter economic analysis when production or allocation depends on it, while its ecological meaning remains irreducible to economics. The boundary therefore permits interdisciplinary interfaces without absorbing neighboring domains.

Domain specification also includes scale. A problem can be economic at the level of a household relation, organization, market, infrastructure, region, state, transnational network, or planetary resource system. The relevant level depends on the generative relations under study. Chapter 12 develops these scales through substantive economic architecture.

11.28.2 Economic Interpretation of General Practical Objects

The general objects developed in Parts II–IV acquire economic semantics only through a concrete field. A historical-relational subject can occupy positions as worker, owner, debtor, caregiver, consumer, taxpayer, investor, beneficiary, pro-

Table 11.28: Minimal interface between domain-general application-dominant praxis and substantive GRE.

Domain-general practical object	Economic specification question	Substantive destination in Part V
Subject / entity	Which economic positions, histories, capacities, and recognized entities are relevant to the inquiry?	Chapter 12: subjects, entities, positions, organizations
Relation / higher-order relation	Which relations organize access, production, exchange, obligation, dependency, coordination, ownership, care, knowledge, or authority?	Chapter 12: relational architecture
Resource / capacity / constraint	Which economically relevant resources, access relations, capacities, infrastructures, and constraints shape reachable action?	Chapters 12–13: resources, capacities, allocation
Practical orientation / evaluative frame	Which economic values, protections, distributions, obligations, and future possibilities matter for the intervention?	Chapters 13–14: allocation and generative value
Institution / rule / field	Which stabilized arrangements organize economic possibility and transformation?	Chapters 12 and 15: institutions, fields, multiscale history
Representation / epistemic event	Which prices, accounts, indicators, classifications, forecasts, scores, or models represent and potentially reshape economic relations?	Chapters 12–15 and Part VI: representation, value, power, knowledge
History / transition structure	Which event orderings, timescales, path dependencies, critical transitions, and generated possibilities matter?	Chapter 15: generative spacetime

ducer, platform participant, institution, household, or collective actor, but these labels do not exhaust the subject's relational history. A resource can be material, financial, informational, institutional, ecological, social, technical, or symbolic depending on how it conditions economic capacity and access. A relation can concern ownership, obligation, exchange, production, dependence, care, authority, credit, recognition, or coordination.

The methodological point is that economic specification selects which of these relations matter for the practical question while retaining the wider historical-relational subject when omitted relations could change the analysis. GRE therefore resists a fixed list of economic primitives at this transition stage. The substantive chapters

can stabilize concepts where the argument and evidence justify them.

Definition 11.516 (Minimal economic specification). A *minimal economic specification* identifies, at a resolution appropriate to the inquiry, the economic positions, relations, resources or capacities, institutions, value-relevant interfaces, representations, historical conditions, and practical scales required to interpret the general methodology of application-dominant praxis within the selected economic field.

Minimal specification is deliberately thinner than a full model. It can be expressed through prose, institutional mapping, formal representation, empirical variables, historical reconstruction, or mixed methods. Its adequacy depends on whether the selected objects preserve the economic relations necessary for the decision or research question.

11.28.3 Economic Representations and Performative Interfaces

Economic fields are unusually rich in consequential representations. Prices, accounts, budgets, classifications, ratings, forecasts, indices, contracts, valuations, scores, models, and public announcements can describe economic relations and can also contribute to changing them. Chapter 5 developed the general epistemology of performative representation, and Sections 11.4 and 11.26 developed the practical conditions under which epistemic uptake and formal decision systems become part of intervention history.

Economic specification therefore asks which representations enter the field, how they acquire authority, who can contest them, and through which relations their uptake changes access, expectation, allocation, investment, obligation, or institutional response. The substantive analysis can then determine whether a representation is merely descriptive, practically performative, or both at different stages.

Representation also provides one interface to value. A valuation can make heterogeneous objects comparable within a particular practice. An accounting rule can determine what enters an institutional decision. A price can coordinate exchange while leaving other value forms outside the transaction. GRE later examines heterogeneous value, conversion, circulation, return, capture, dissipation, and regeneration. Chapter 11 requires only that the practical use of economic representations preserve their provenance and possible performative effects.

Machine-mediated representations fit the same interface. A learned forecast, classification, or recommendation can be economically consequential through its institutional uptake. Its technical properties can matter greatly, while the domain-general boundary conditions of normative provenance, responsibility, human-relational distance, temporal transport, regime sensitivity, and reflexivity remain relevant regardless of whether the representation was generated by AI or by another formal system.

11.28.4 Handoff to Substantive GRE

The transition to Part V can now be stated compactly. Application-dominant GR provides a meta-methodological repertoire for situated orientation, practical diagnosis, evidence-to-commitment translation, evolving action spaces, scenario construction, robustness, adaptation, critical-transition uncertainty, formal and interpretive anal-

ysis, participation, intervention composition, monitoring, repair, exit, and recursive revision. Economic specification assigns these methods to economic objects whose substantive content must be reconstructed historically and empirically.

Chapter 12 develops the *Relational Architecture of Economic Systems*. It specifies how economic subjects, entities, relations, organizations, institutions, markets, households, commons, platforms, infrastructures, resources, capacities, access, ownership, transfer, labor, coordination, dependency, asymmetry, symbolic relations, topology, fields, multiscale history, and generative potential can be represented within GRE. These objects are therefore introduced there in substantive form rather than anticipated exhaustively here.

Chapter 13 develops *Allocation as Relational Intervention*. The general intervention architecture of Part IV reappears with explicitly economic semantics: allocation changes access, capacities, constraints, obligations, dependencies, and future action spaces. Chapter 14 develops *Generative Value*, including heterogeneous value, conversion, circulation, transmission, return, capture, dissipation, regeneration, and justice. Chapter 15 develops *Generative Spacetime*, where event ordering, timescales, path dependence, fields, attractors, transition structure, and other locally justified representations receive economic interpretation.

The handoff preserves two boundaries. First, economic specification does not convert every relational phenomenon into economics. Neighboring legal, political, educational, ecological, historical, cultural, and technological processes retain their own analytical standing even when they interact with economic relations. Second, the general methodology does not predetermine one substantive economic ontology. Part V remains responsible for constructing, testing, and revising the economic objects required by GRE.

Chapter 11 therefore closes at the interface between method and domain. Its outcome is a configurable architecture for consequential praxis whose evaluative frames, epistemic conditions, formal models, intervention dimensions, responsibility relations, and reopening rules remain historically situated. Section 311 begins the substantive economic programme by specifying the economic domain at a level appropriate to the relational architecture developed in Chapter 12.

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