

Engineering Complex Human-Technological Work Systems – A Sensemaking Approach

Paper I-030

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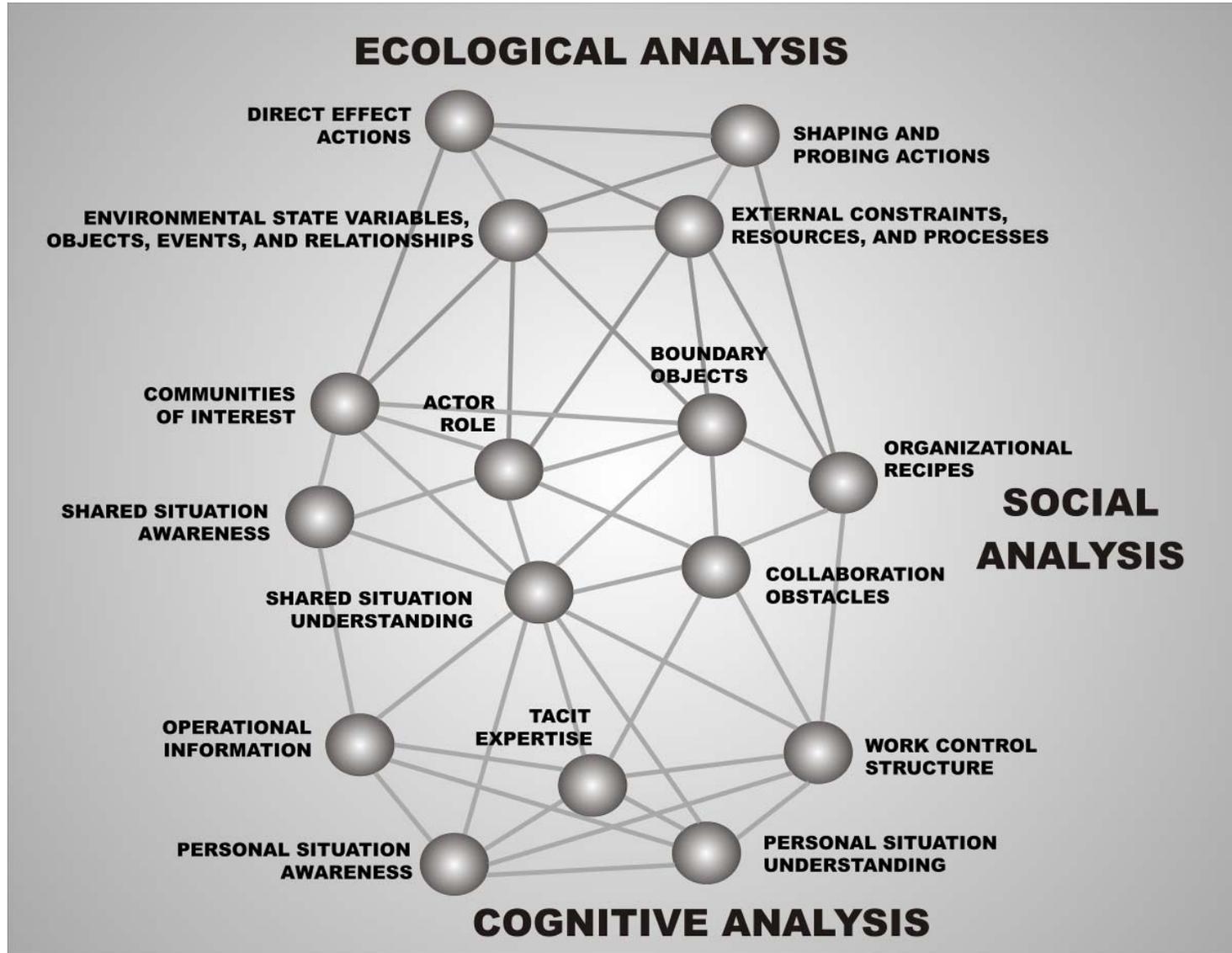
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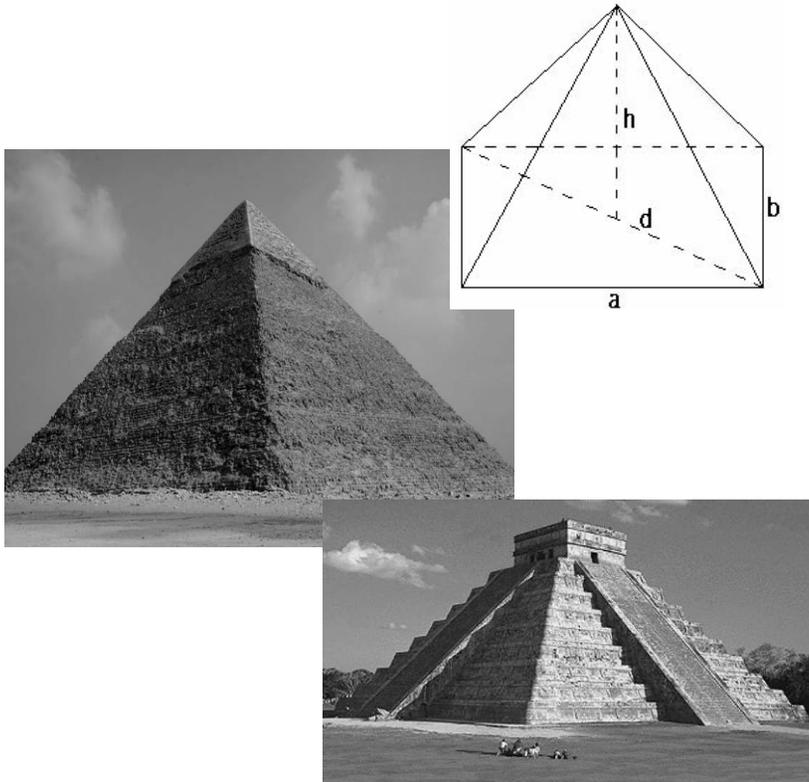
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Levels of Work Systems Analysis



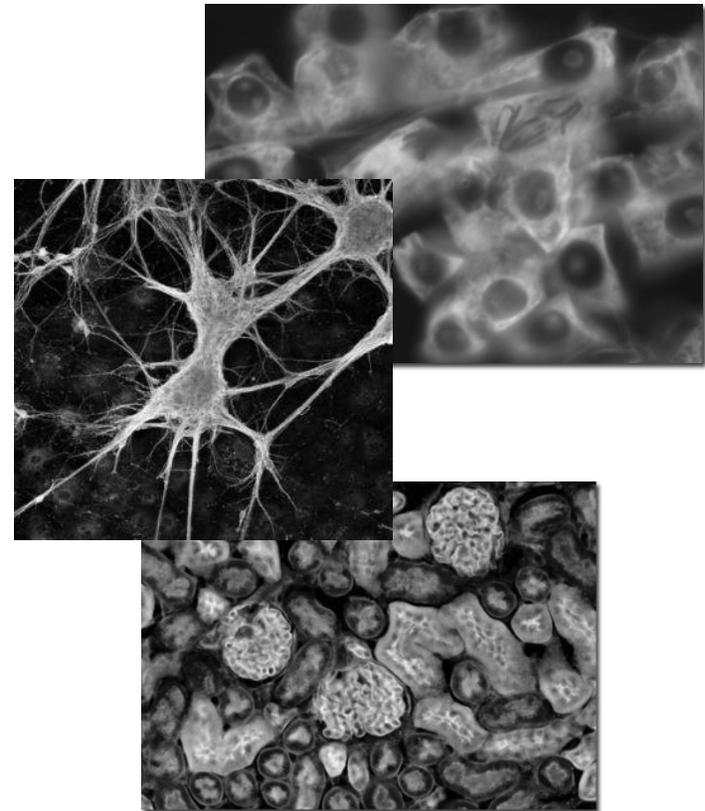
Two Views of the World

The way engineers think about systems...



Architecture / Mathematics

The way systems actually work...

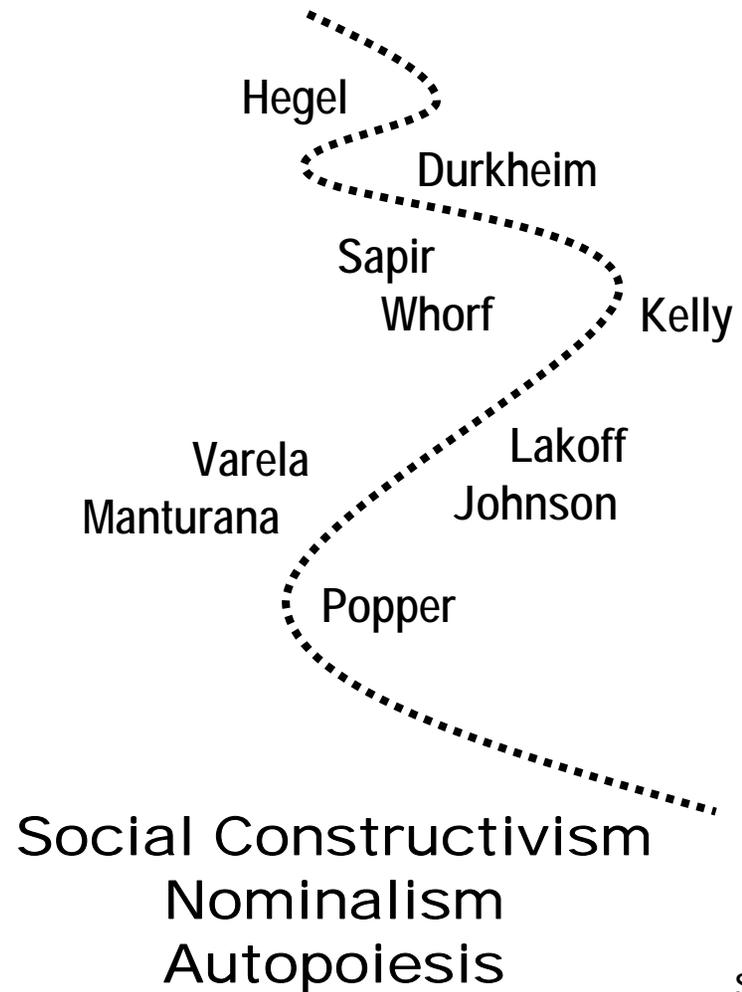
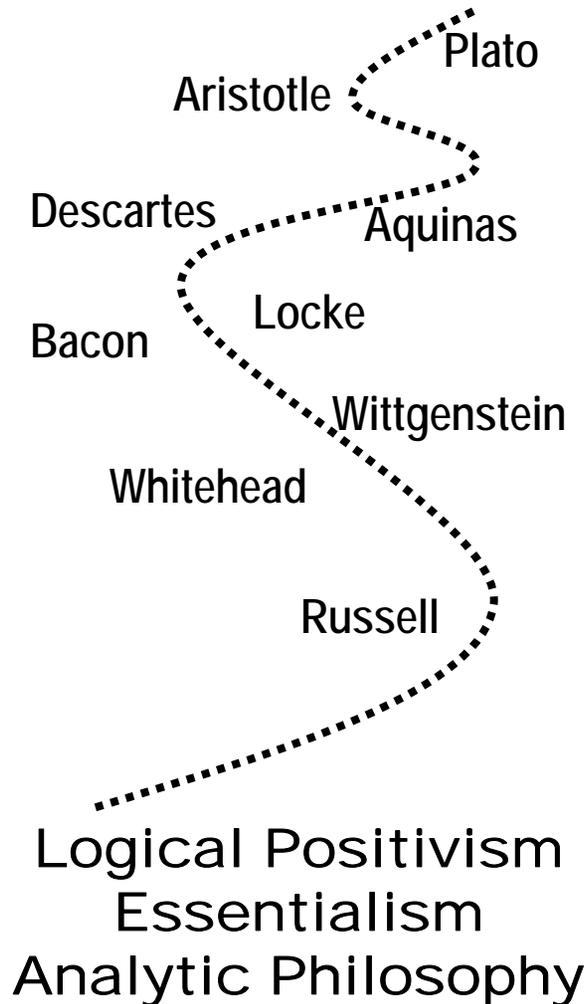


Biology

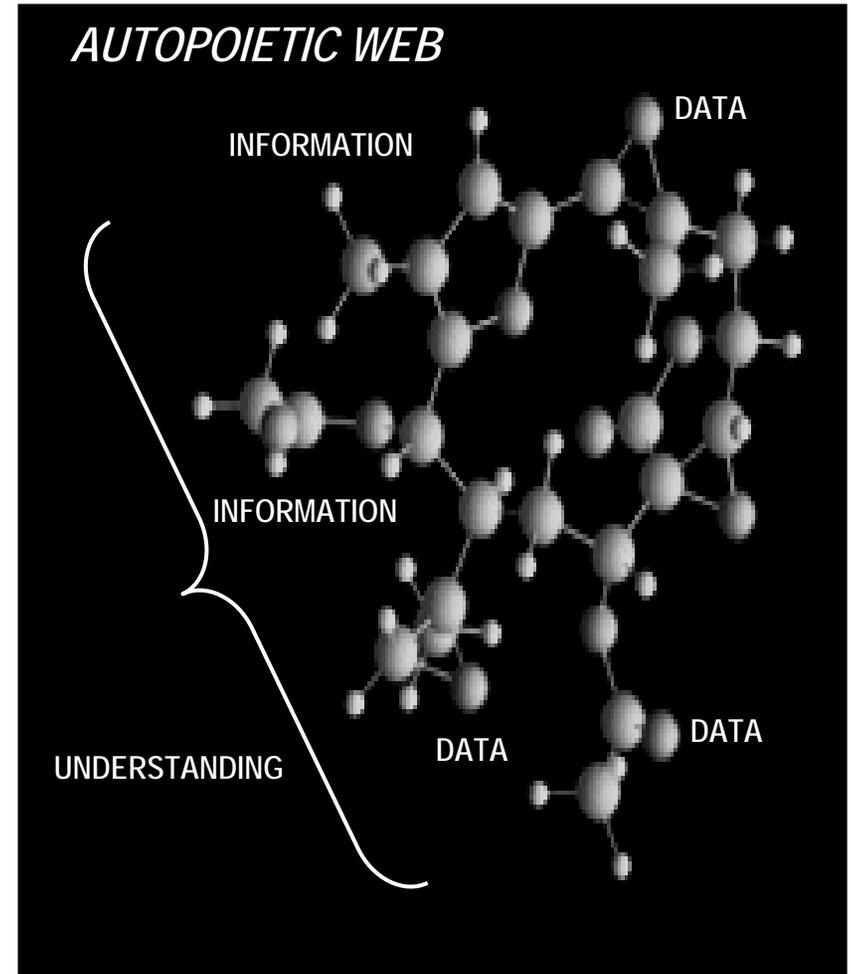
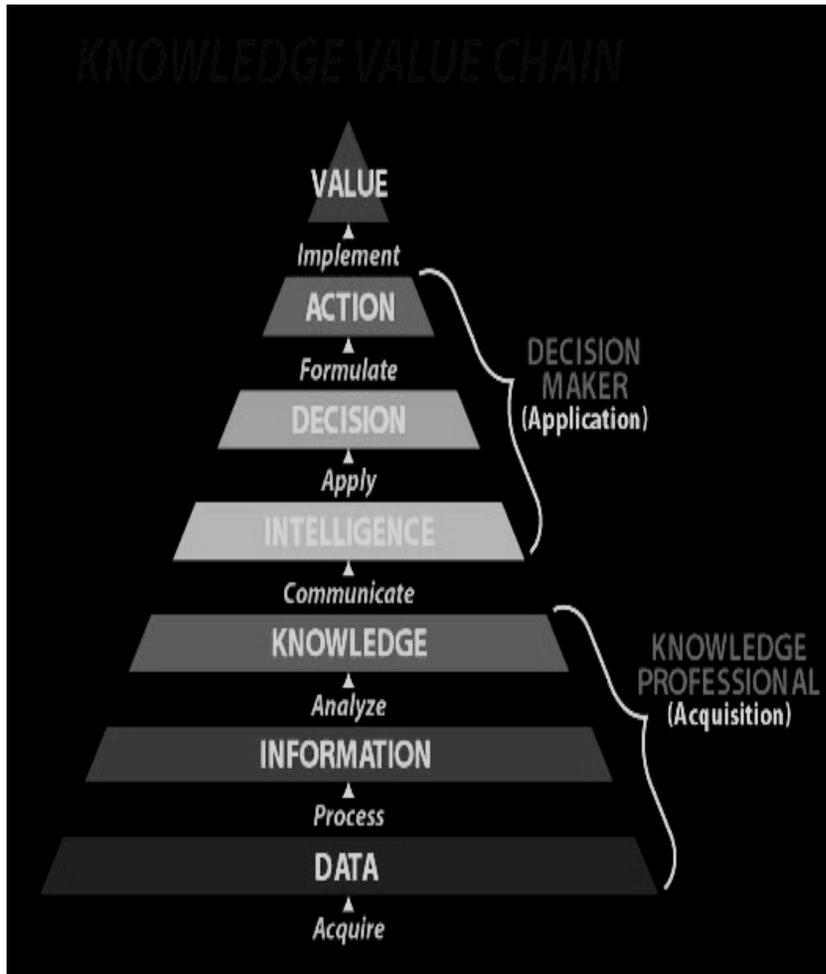
Two Philosophical Traditions

Classical-Positivist

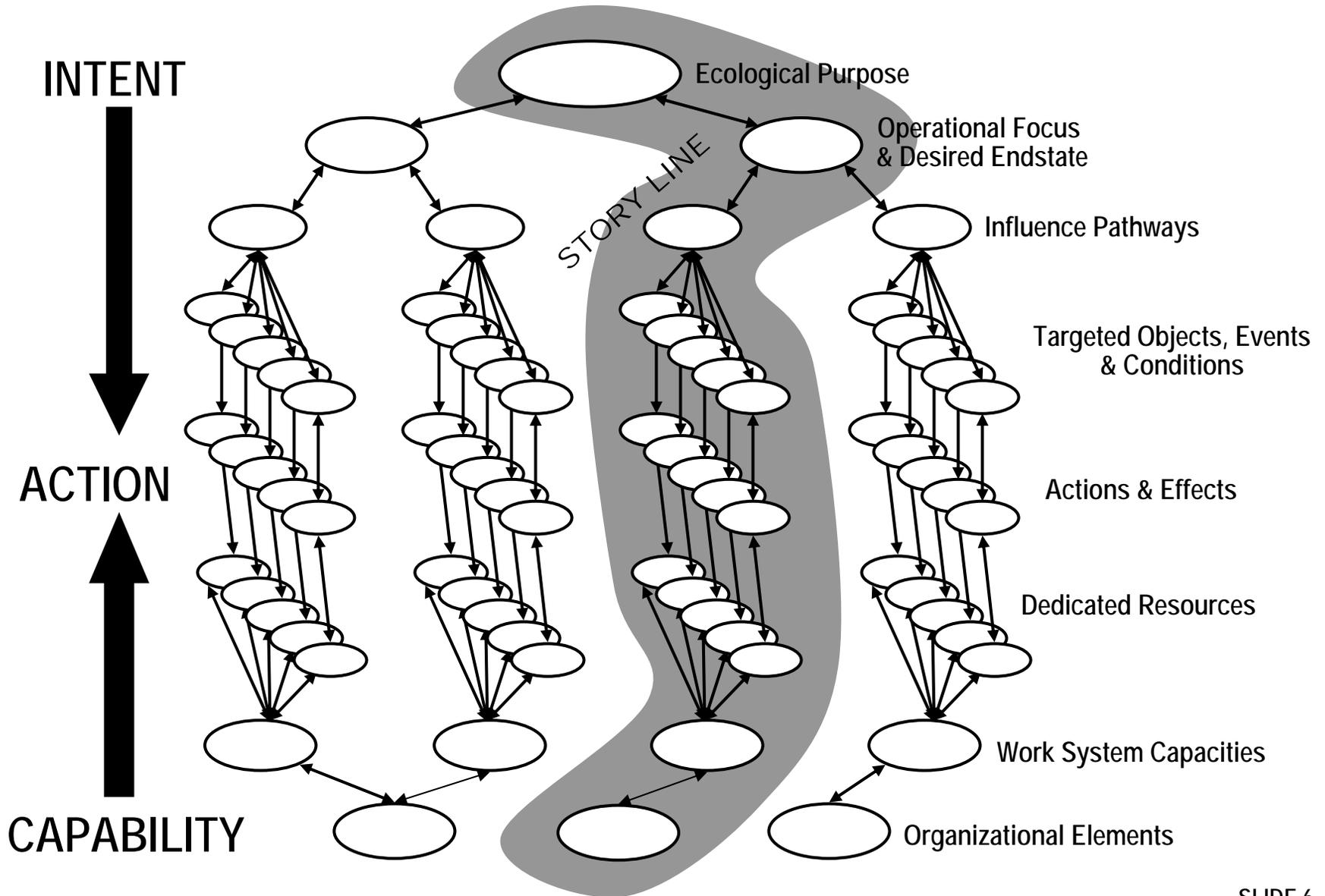
Sensemaking-Constructivist



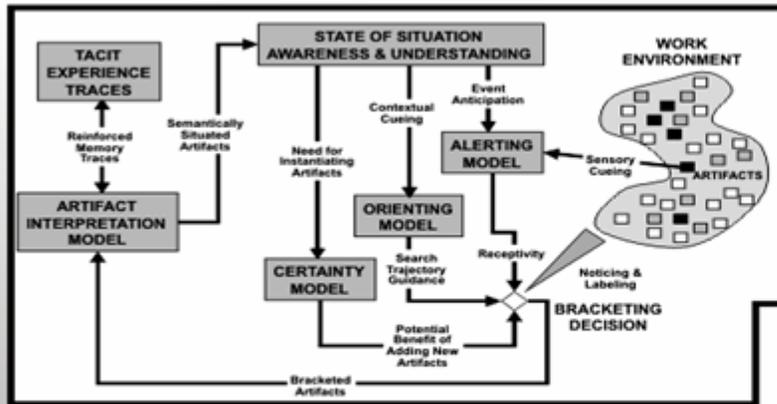
Two Views of Data-Information-Knowledge



Work Control Structure



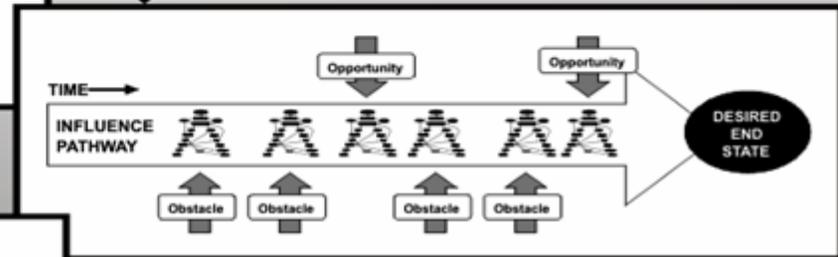
Sensemaking - Cognitive Level



BRACKETING & INTERPRETATION MODEL

*Semantically
Situated
Artifacts*

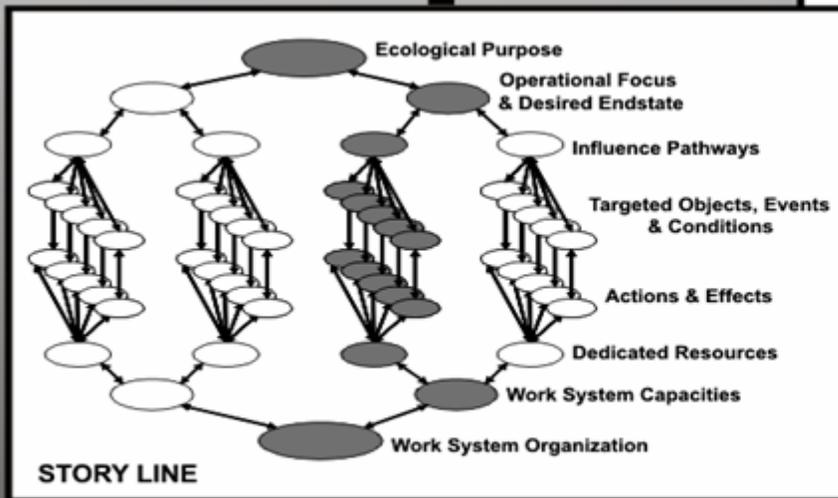
INFLUENCE PATHWAY MODEL



*Associated
Actions & Effects*

*Process is repeated in an iterative
fashion until the work system
achieves the desired endstate*

MEANS-ENDS MAPPING MODEL



Bracketing and Interpretation Issues

Central Question: Ability of actors to recognize appropriate types of data from the environment relative to their constructed framework of understanding

- How does the actor's framework of understanding trigger and orient the actor's attention to specific classes of work-relevant artifacts within the environment?
- To what degree is the actor's bracketing process influenced by internally-generated alerting cues versus externally-generated sensory cues –*i.e.*, to what degree is the bracketing process driven in a top-down versus bottom-up manner.
- How does the actor judge the information value of specific artifacts relative to specific areas of uncertainty and ambiguity within his state of understanding?
- How do specific areas of the actor's tacit experience affect his ability to semantically interpret bracketed artifacts and use them to instantiate different parts of his overall framework of understanding?

Influence Pathway Development Issues

Central Question: Organization of action trajectories along specific pathways of influence within the work system's constructed problem domain

- What types of influence pathways are relevant to the ecological purpose of the work system, and how are these pathways defined in terms of specific areas of operational focus and desired endstates?
- What types of obstacles and opportunities are likely to emerge within the environment relative to each pathway of influence?
- How do specific areas of the actor's tacit experience affect his ability to recognize these obstacles and opportunities, and to associate them with specific response actions and effects?
- How do actions taken along one pathway of influence create obstacles and opportunities along another pathway –i.e., in what ways are these pathways functionally cross-linked?

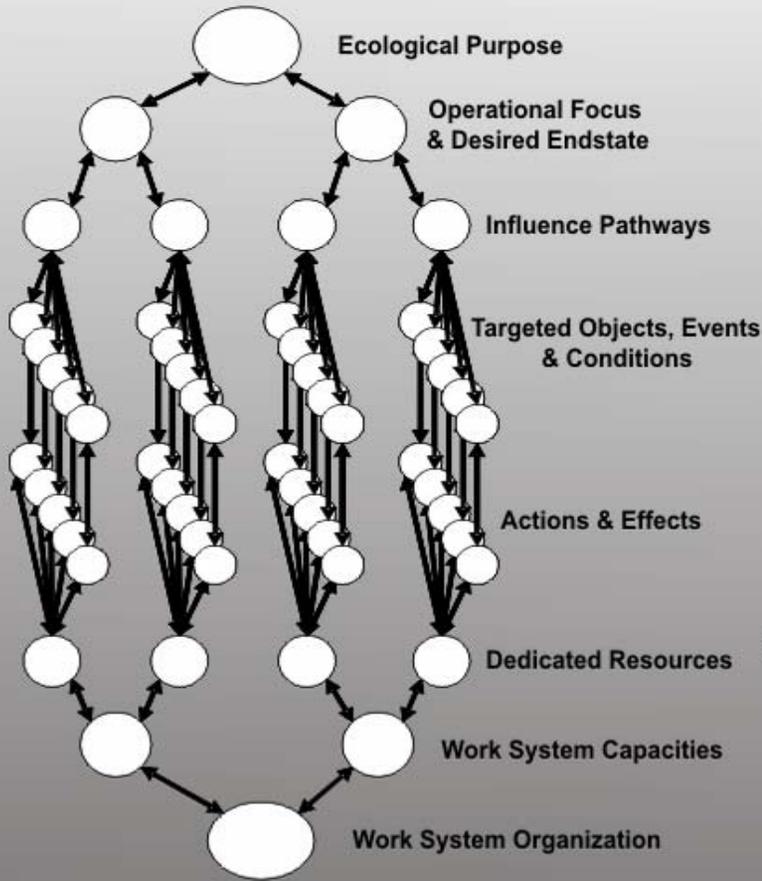
Means-Ends Mapping Issues

Central Question: The articulation of work system behavior in terms of emergent story lines

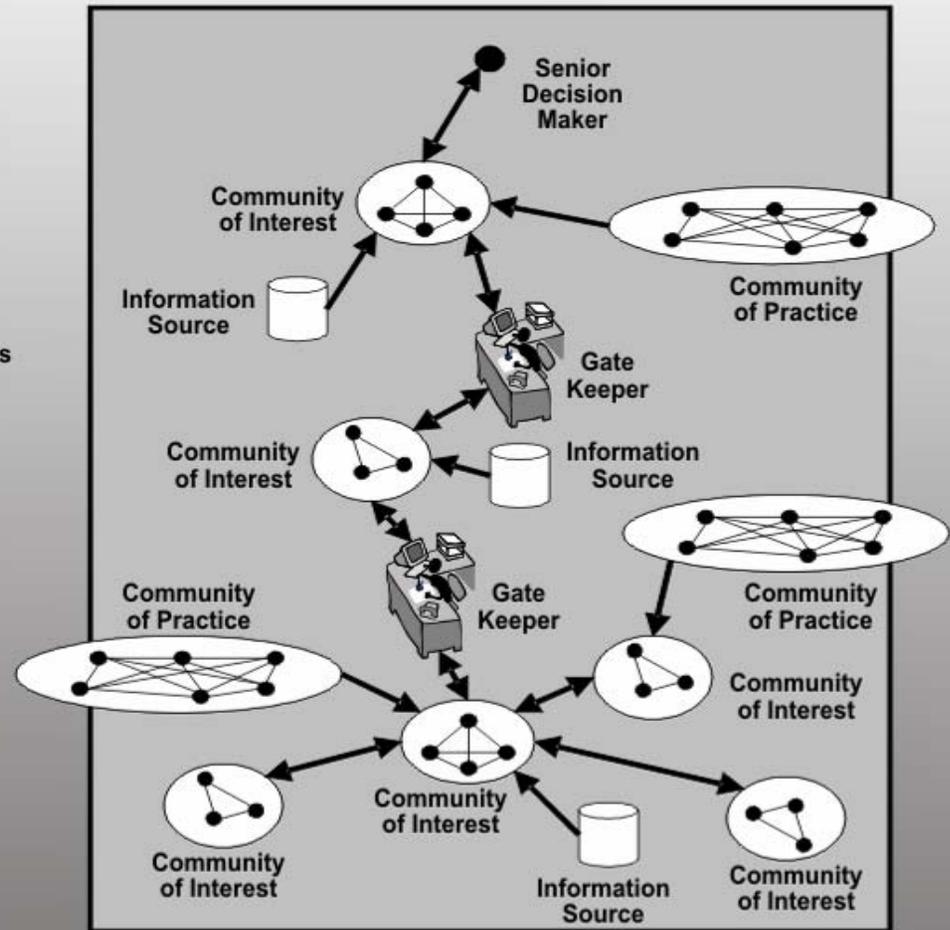
- What types of story lines constitute the attention and focus of a work system?
- What are the different levels of thinking involved in creating these story lines?
- How are different parts of the work control structure constructed by different actors, each having unique areas of tacit experience and task responsibility?
- What types of knowledge management obstacles and bottlenecks exist across different areas of a work system's work control structure?
- What types of knowledge gaps (e.g., areas of uncertainty, ambiguity, equivocality) can arise across the work control structure and how do each of these gaps influence the work system's gathering and interpretation of artifacts from its environment?

Sensemaking – Social Level

EPISTEMOLOGICAL VIEW



ORGANIZATIONAL VIEW



Specific Mechanisms of Collaboration

Central Question: The ability of actors to contribute their unique areas of expertise to the functioning of the work system

- The effectiveness and efficiency by which one actor can draw the attention of other actors to a specific set of artifacts and cues, including explicit representation and assessment of the specific types of organizational, pricing, and cultural obstacles that impede this process
- The impact of specific types of obstacles (e.g., role, reputation, trust, culture, proximity, status, and parochialism) on the ability of specific actors to contribute their awareness and understanding to formed communities of interest within a work system
- The resulting effect of these collaboration obstacles on the creation of critical awareness and understanding at each point in the work system's development of its overall work control structure (e.g., the cascading effect of knowledge voids as the set of actors within a work system construct an understanding of how intent and capability can be combined to produce purposeful actions)

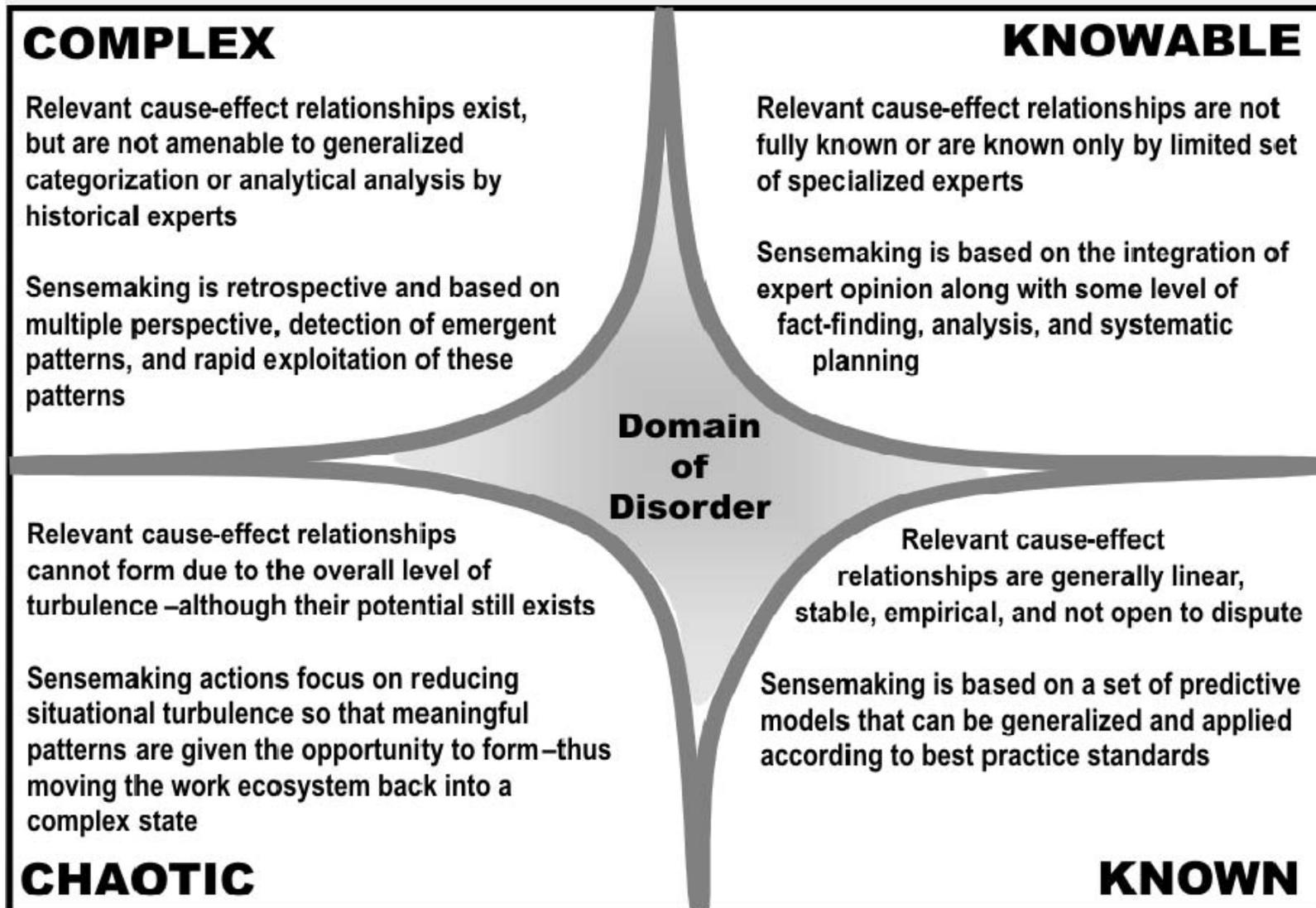
Central Question: Identifying and overcoming specific forms of knowledge differences across a work system

- Identification and classification of specific epistemological boundaries that critical impact on the ability of the work system to form a coherent understanding of a problem domain
- The impact of these boundaries at each point in the work system's development of its overall work control structure
- The relative need for unified taxonomies and shared language versus the need for communities of practice, mentoring relationships, and communities of interest across a work system (*i.e.*, which approaches to overcoming each type of boundary will be effective or counterproductive)

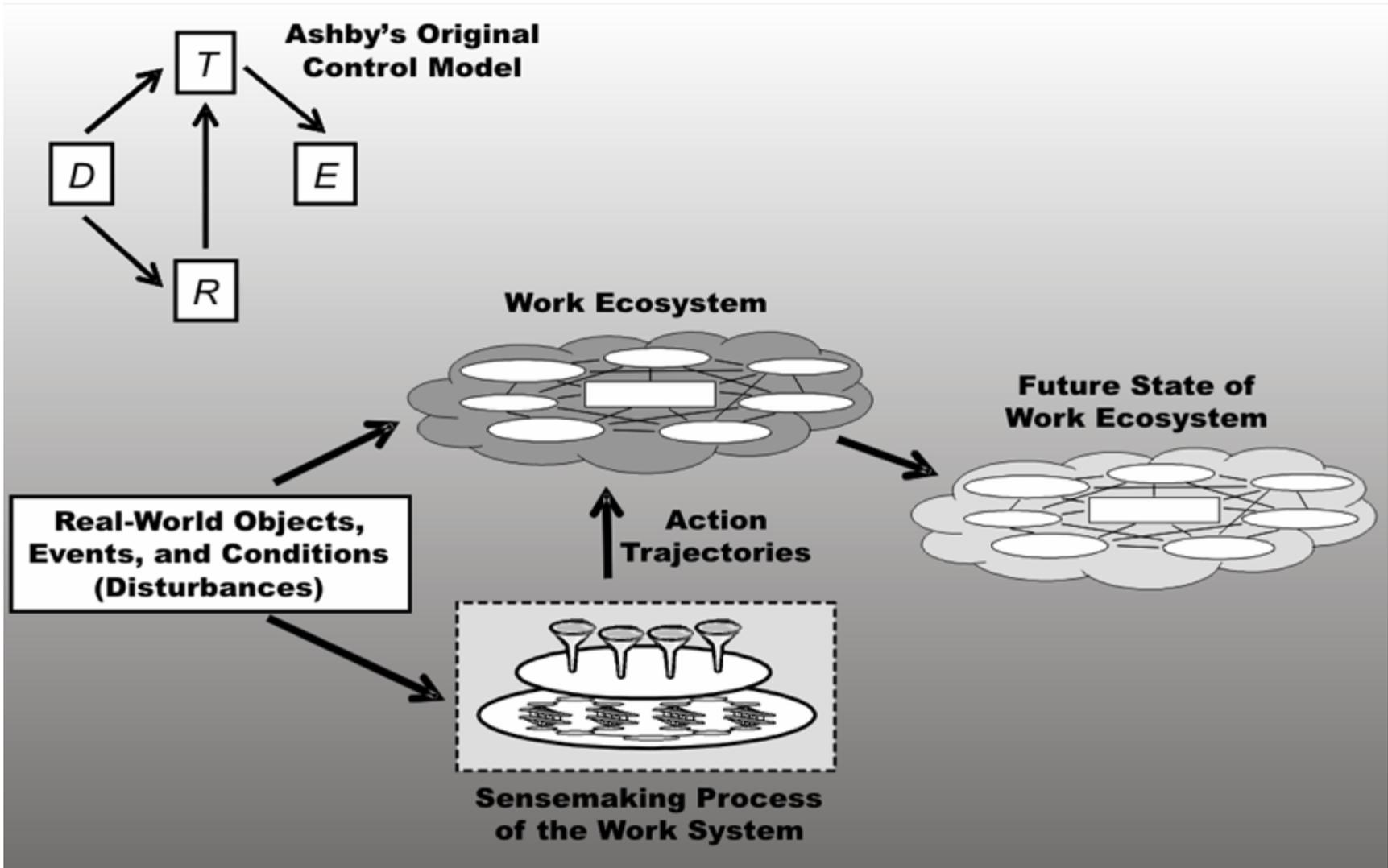
Central Question: The impact of training, personnel management, technology, and organizational design interventions on the distributed knowledge creation process within a work system

- *Training* – the impact of personnel training on (1) individual actor expertise, (2) collaborative work performance, and (3) oversight and management of the distributed knowledge creation process across a work system
- *Personnel Management* – the impact of changing personnel management policies regarding (1) key work assignments, (2) personnel assignment duration and rotation frequency, and (3) collaborative work opportunities
- *Information Technology* – the ability of decision support systems to augment or replace human actors in critical areas such as (1) maintaining the breadth and depth of situation awareness and understanding and (2) reconciling conflicting goals and constraints
- *Collaborative Work Technology* – the ability of computer supported collaborative work systems to overcome various types of organizational, pricing, and cultural obstacles to effective knowledge creation in communities of interest
- *Work Flow Design* – the impact of changing work flow architecture regarding (1) the creation of specific communities of interest (e.g., councils, working groups, project groups, and ad hoc teams), (2) boundary object definition and flow, (3) organizational recipes, (4) information flow, (5) formal and informal actor networks, and (6) workspace

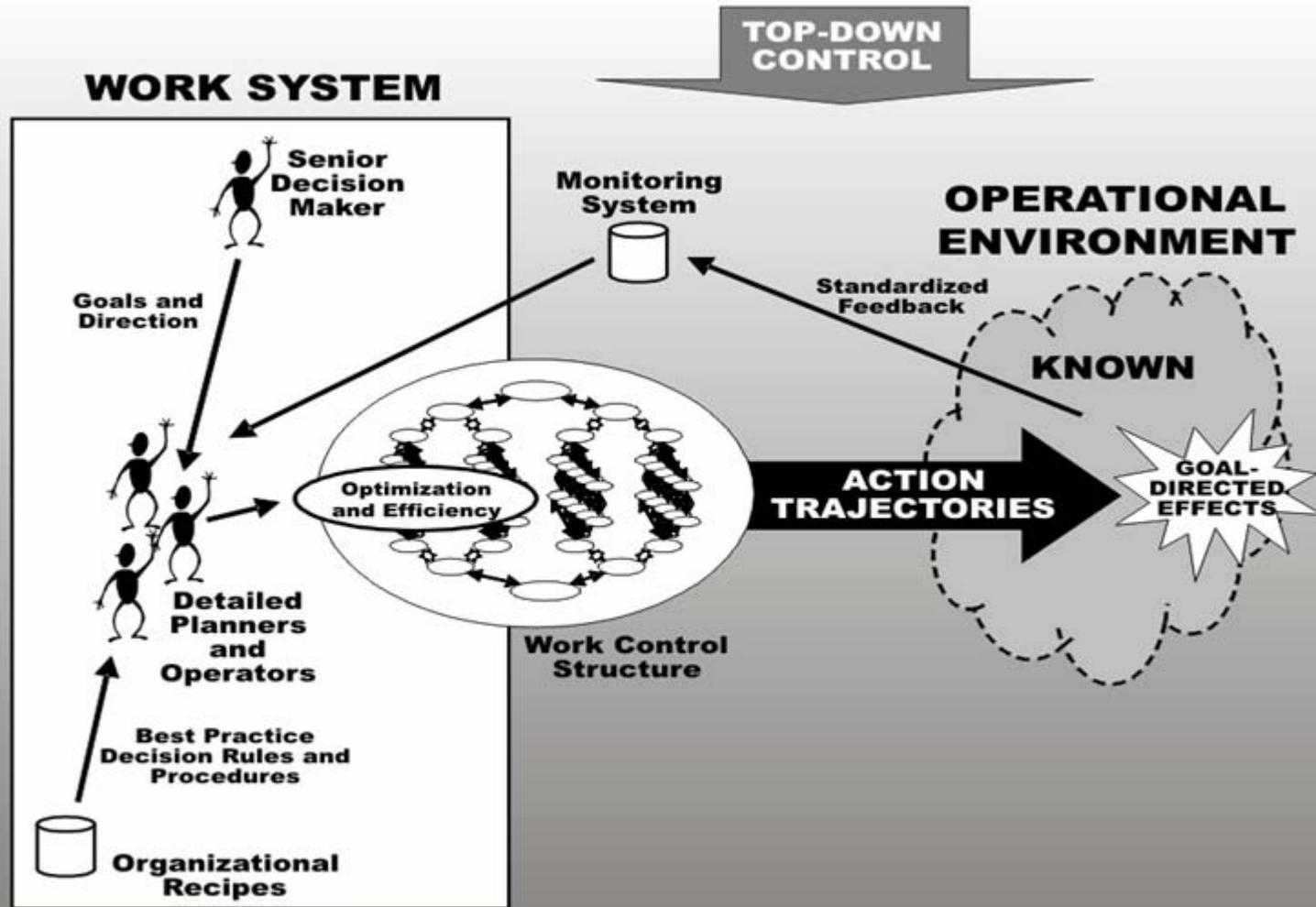
Cynefin Sensemaking Model



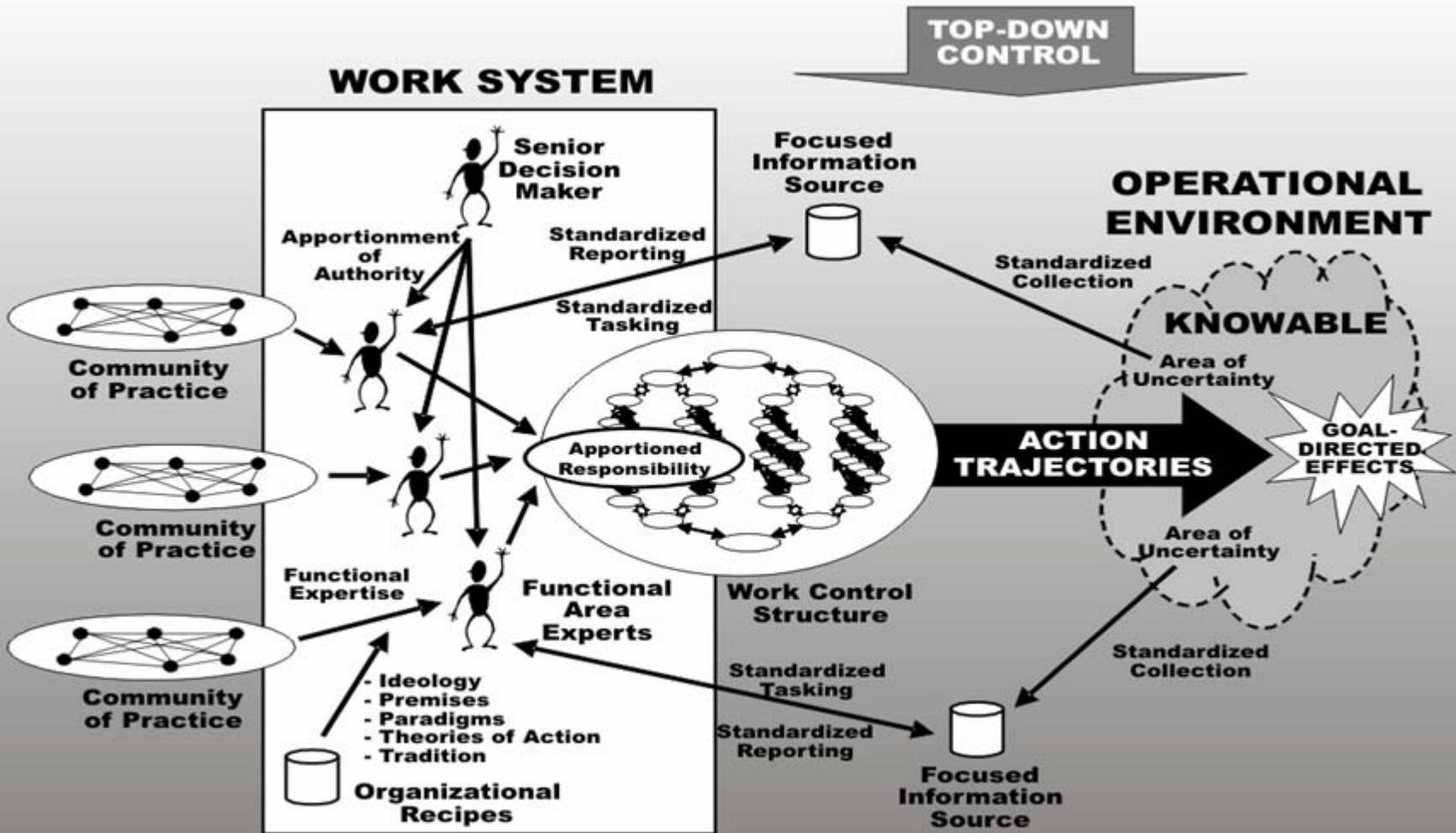
Law of Requisite Variety



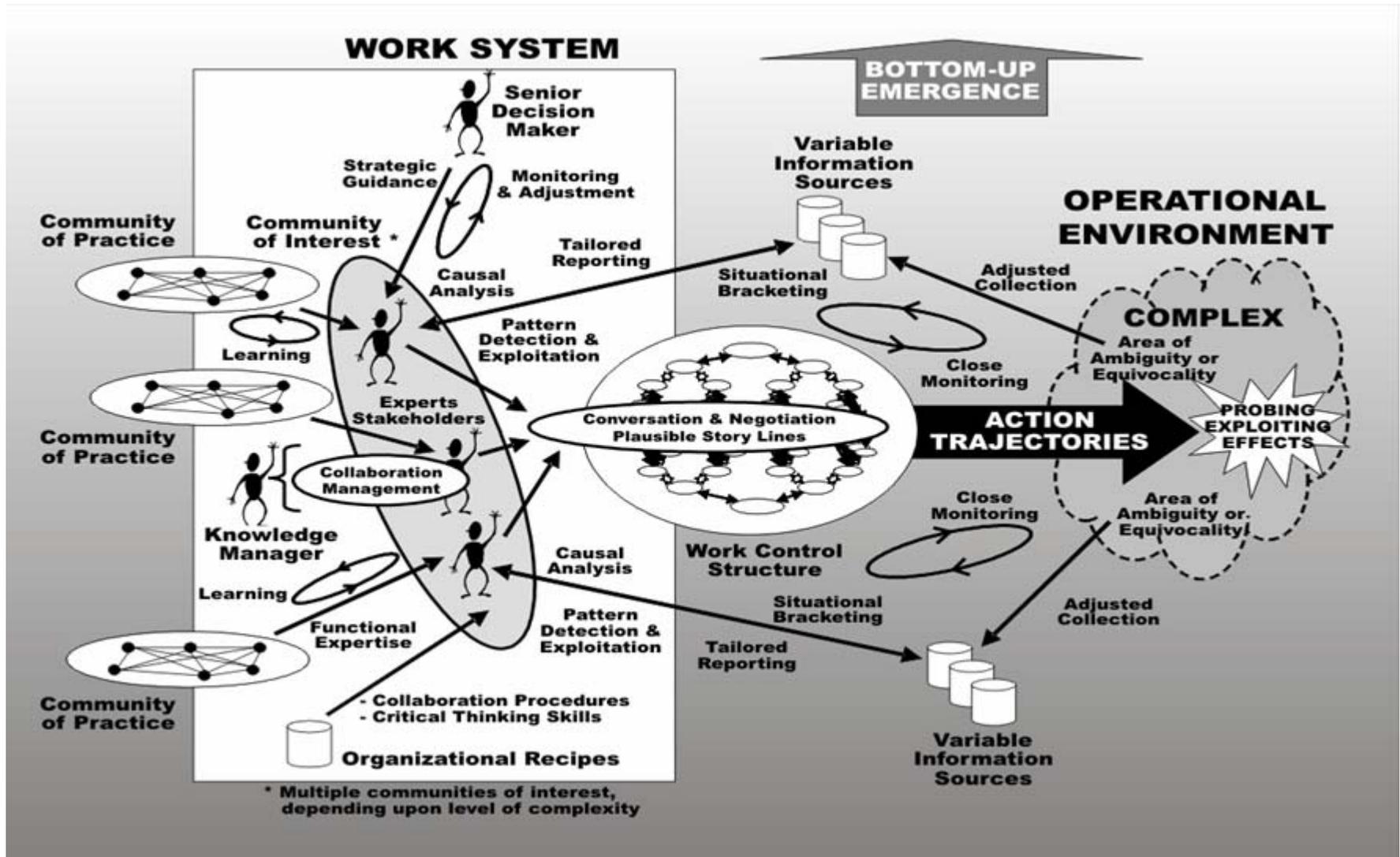
Sensemaking – Known Environment



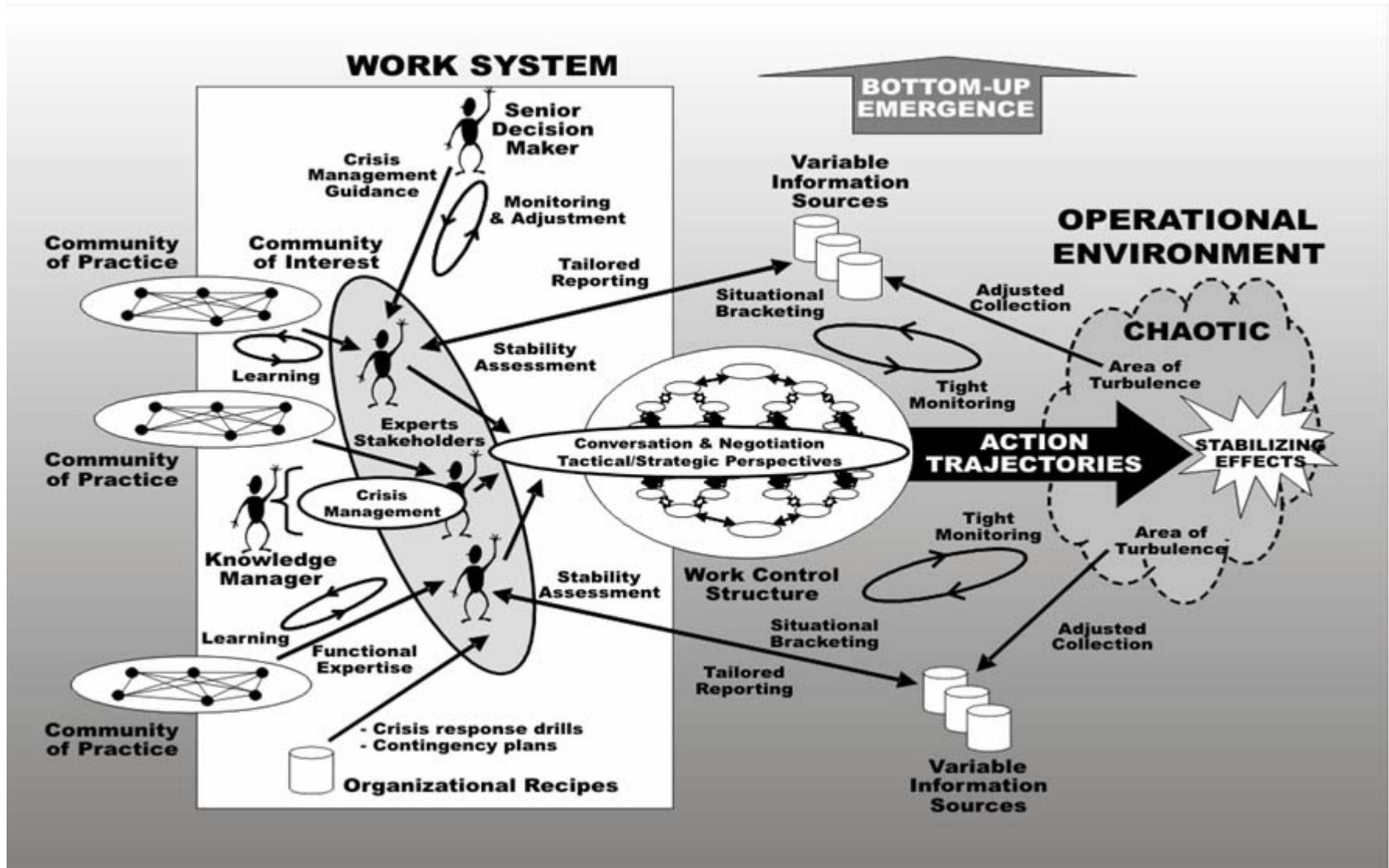
Sensemaking – Knowable Environment



Sensemaking – Complex Environment



Sensemaking – Chaotic Environment



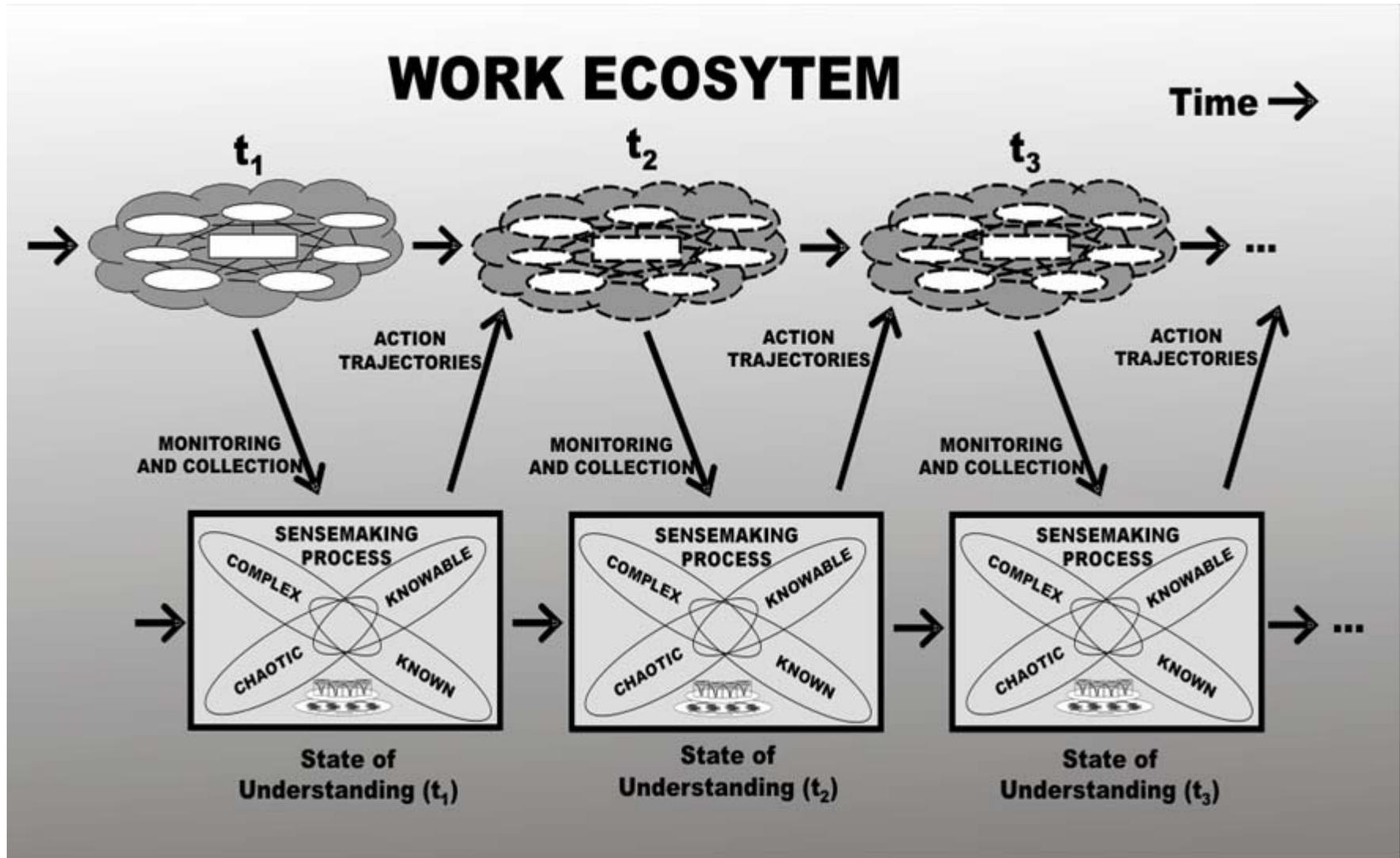
Elements of Sensemaking Agility

← **KNOWN KNOWABLE COMPLEX CHAOTIC** →

ELEMENTS OF AGILITY

WORK ECOSYSTEM ONTOLOGY	• Cause-effect relationships known and universal	• Cause-effect relationships partially known or known only by a few experts	• Cause-effect relationships emerge over time, but do not repeat	• Cause-effect relationships emerge only when turbulence is reduced
FORM OF CONTROL	• Top-down, directive • Centralized	• Top-down, directive • Distributed	• Bottom-up, emergent • Negotiated	• Bottom-up, emergent • Both tactical and strategic
SENIOR DECISION MAKER	• Goals and direction • Strong coupling	• Apportioned authority • Strong coupling	• Strategic guidance • Weak coupling	• Crisis mgmt guidance • Weak coupling
STAKEHOLDER INTERESTS	N/A	N/A	• Competing strategic goals and constraints	• Competing response drills and contingency plans
FUNCTIONAL EXPERTS	N/A	• Provides unique areas of relevant experience	• Provides unique areas of abductive reasoning	• Provides unique response drills / contingency plans
KNOWLEDGE CREATION	• Primarily rule-based • Universally shared	• Pattern recognition-based • Specialized, historical	• Critical thinking skills • Little historical relevance	• Response drill-based • Tactical time horizon
COMMUNITIES OF PRACTICE	N/A	• Provides best practice standards	• Provides best practice standards and learning	• Provides best practice standards
COMMUNITIES OF INTEREST	N/A	N/A	• Enables conversation, negotiation of WCS, and development of plausible story lines	• Enables conversation, negotiation of WCS, and balancing of tactical actions with strategic goals
KNOWLEDGE MANAGER	N/A	N/A	• Manages COIs relative to strategic guidance	• Manages COIs relative to crisis mgmt guidance
ORGANIZATIONAL RECIPES	• Decision rules and work procedures	• Ideology, premises, paradigms, theories of action, tradition	• Collaboration procedures • Critical thinking skills	• Crisis response drills • Contingency plans
INFORMATION SYSTEMS	• Fixed monitoring • Standardized feedback	• Focused info sources • Standardized collection	• Close monitoring • Variable info sources • Adjusted collection	• Tight monitoring • Variable info sources • Adjusted collection
WORK CONTROL STRUCTURE	• Unified • Stable	• Unified • Stable	• Negotiated • Emergent	• Negotiated • Both tactical and strategic
ACTIONS AND EFFECTS	• Goal-directed • Optimized	• Goal-directed • Optimized	• Probe and exploit • Opportunistic, incremental	• Stabilizing • Deconflicted with strategic goals

Continuous Nature of Sensemaking



- **Appropriate characterization of the operational environment**
 - The degree of ontological order that characterizes different portions or aspects of a work system's operational domain
 - The potential for portions of the environment to shift from one type of sensemaking environment to another over time (i.e., the relative requirement for work system agility across known, knowable, complex, chaotic sensemaking environments)
 - The degree to which work system goals, operational focus points, and influence pathways are constructed and maintained in a top-down versus bottom-up manner
- **The relative need for collaboration**
 - The types of communities of interest needed to provide bodies of expertise relevant to different parts of the operational environment;
 - The focus, composition, and organizational positioning of specifically formed communities of interest needed within the work system to address critical areas of operational ambiguity, equivocality, and competing interests; and
 - The relative ability of various types of interventions (e.g., training, personnel management, information technology, collaborative work technology, work flow design) to enhance the knowledge creation process in different types of sensemaking environments
- **Work system agility**
 - The agility of a work system's sensemaking process to adapt across known, knowable, complex, and chaotic sensemaking environments (i.e., specific characterization and assessment of potential points and modes of sensemaking failure inherent within a work system) and
 - The relative ability of various types of interventions (e.g., training, personnel management, information technology, collaborative work technology, work flow design) to enhance work system agility across different types of sensemaking environments