Engineering Complex Human-Technological Work Systems – A Sensemaking Approach

Paper I-030

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Two Views of the World

The way engineers think about systems...

Architecture / Mathematics

The way systems actually work...

Biology
Two Philosophical Traditions

Classical-Positivist

Plato
Aristotle
Descartes
Aquinas
Locke
Wittgenstein
Whitehead
Russell

Logical Positivism
Essentialism
Analytic Philosophy

Sensemaking-Constructivist

Hegel
Durkheim
Sapir
Whorf
Kelly

Varela
Manturana

Lakoff
Popper

Social Constructivism
Nominalism
Autopoiesis
Two Views of Data-Information-Knowledge
Work Control Structure

INTENT

ACTION

CAPABILITY

Ecological Purpose

Operational Focus & Desired Endstate

Influence Pathways

Targeted Objects, Events & Conditions

Actions & Effects

Dedicated Resources

Work System Capacities

Organizational Elements
Sensemaking – Cognitive Level

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PROCESS

INFLUENCE PATHWAY

Ecological Purpose
Operational Focus & Desired Endstate
Influence Pathways
Targeted Objects, Events & Conditions
Actions & Effects
Dedicated Resources
Work System Capacities
Work System Organization

STORY LINE

BRACKETING & INTERPRETATION MODEL

Semantically Situated Artifacts
INFLUENCE PATHWAY MODEL

Time

Opportunity

Desired End State

Associated Actions & Effects

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

MEANS-ENDS MAPPING MODEL
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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?
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?
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**
- Ecological Purpose
- Operational Focus & Desired Endstate
- Influence Pathways
- Targeted Objects, Events & Conditions
- Actions & Effects
- Dedicated Resources
- Work System Capacities
- Work System Organization

**ORGANIZATIONAL VIEW**
- Senior Decision Maker
- Community of Interest
- Information Source
- Gate Keeper
- Community of Practice
- Community of Interest
- Information Source
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

**COMPLEX**
Relevant cause-effect relationships exist, but are not amenable to generalized categorization or analytical analysis by historical experts.

Sensemaking is retrospective and based on multiple perspective, detection of emergent patterns, and rapid exploitation of these patterns.

**CHAOTIC**
Relevant cause-effect relationships cannot form due to the overall level of turbulence – although their potential still exists.

Sensemaking actions focus on reducing situational turbulence so that meaningful patterns are given the opportunity to form – thus moving the work ecosystem back into a complex state.

**KNOWABLE**
Relevant cause-effect relationships are not fully known or are known only by limited set of specialized experts.

Sensemaking is based on the integration of expert opinion along with some level of fact-finding, analysis, and systematic planning.

**KNOWN**
Relevant cause-effect relationships are generally linear, stable, empirical, and not open to dispute.

Sensemaking is based on a set of predictive models that can be generalized and applied according to best practice standards.

Domain of Disorder
Law of Requisite Variety

Ashby’s Original Control Model

Work Ecosystem

Real-World Objects, Events, and Conditions (Disturbances)

Sensemaking Process of the Work System

Future State of Work Ecosystem
Sensemaking – Knowable Environment
Sensemaking – Complex Environment

WORK SYSTEM

- Senior Decision Maker
- Strategic Guidance
- Monitoring & Adjustment
- Tailored Reporting

COMMUNITY OF INTEREST *
- Causal Analysis
- Pattern Detection & Exploitation
- Conversation & Negotiation Plausible Story Lines

- Senior Decision Maker
- Strategic Guidance
- Monitoring & Adjustment
- Tailored Reporting

Variable Information Sources

BOTTOM-UP EMERGENCE

OPERATIONAL ENVIRONMENT

- Variable Information Sources
- Situational Bracketing
- Adjusted Collection
- Close Monitoring

COMPLEX

ACTION TRAJECTORIES

- Probing Exploiting Effects
- Area of Ambiguity or Equivoical
- Adjusted Collection
- Close Monitoring

COMMUNITY OF PRACTICE
- Collaboration Management
- Knowledge Manager
- Functional Expertise
- Collaboration Procedures - Critical Thinking Skills
- Organizational Recipes

* Multiple communities of interest, depending upon level of complexity

Engineering Complex Human-Technological Work Systems.
Sensemaking – Chaotic Environment
# Elements of Sensemaking Agility

## Known Knowable Complex Chaotic

<table>
<thead>
<tr>
<th>Elements of Agility</th>
<th>Known</th>
<th>Knowable</th>
<th>Complex</th>
<th>Chaotic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Form of Control</strong></td>
<td>Top-down, directive</td>
<td>Top-down, directive</td>
<td>Bottom-up, emergent</td>
<td>Bottom-up, emergent</td>
</tr>
<tr>
<td><strong>Senior Decision Maker</strong></td>
<td>Goals and direction</td>
<td>Apportioned authority</td>
<td>Strategic guidance</td>
<td>Crisis mgt guidance</td>
</tr>
<tr>
<td><strong>Stakeholder Interests</strong></td>
<td>Strong coupling</td>
<td>Strong coupling</td>
<td>Weak coupling</td>
<td>Weak coupling</td>
</tr>
<tr>
<td><strong>Functional Experts</strong></td>
<td>N/A</td>
<td>N/A</td>
<td>Competing strategic goals and constraints</td>
<td>Competing response drills and contingency plans</td>
</tr>
<tr>
<td><strong>Knowledge Creation</strong></td>
<td>Primarily rule-based</td>
<td>Pattern recognition-based</td>
<td>Critical thinking skills</td>
<td>Little historical relevance</td>
</tr>
<tr>
<td><strong>Communities of Practice</strong></td>
<td>Universally shared</td>
<td>Specialized, historical</td>
<td>Response drill-based</td>
<td>Tactical time horizon</td>
</tr>
<tr>
<td><strong>Communities of Interest</strong></td>
<td>N/A</td>
<td>Provides best practice standards</td>
<td>Provides best practice standards</td>
<td>Provides best practice standards</td>
</tr>
<tr>
<td><strong>Knowledge Manager</strong></td>
<td>N/A</td>
<td>N/A</td>
<td>Enables conversation, negotiation of WCS, and development of plausible story lines</td>
<td>Enables conversation, negotiation of WCS, and balancing of tactical actions with strategic goals</td>
</tr>
<tr>
<td><strong>Organizational Recipes</strong></td>
<td>Decision rules and work procedures</td>
<td>Ideology, premises, paradigms, theories of action, tradition</td>
<td>Collaboration procedures</td>
<td>Crisis response drills</td>
</tr>
<tr>
<td><strong>Information Systems</strong></td>
<td>Fixed monitoring</td>
<td>Focused info sources</td>
<td>Close monitoring</td>
<td>Tight monitoring</td>
</tr>
<tr>
<td><strong>Work Control Structure</strong></td>
<td>Standardized feedback</td>
<td>Standardized collection</td>
<td>Variable info sources</td>
<td>Variable info sources</td>
</tr>
<tr>
<td><strong>Actions and Effects</strong></td>
<td>Unified</td>
<td>Unified</td>
<td>Negotiated</td>
<td>Negotiated</td>
</tr>
<tr>
<td></td>
<td>Stable</td>
<td>Stable</td>
<td>Emergent</td>
<td>Emergent</td>
</tr>
<tr>
<td></td>
<td>Goal-directed</td>
<td>Goal-directed</td>
<td>Probe and exploit</td>
<td>Stabilizing</td>
</tr>
<tr>
<td></td>
<td>Optimized</td>
<td>Optimized</td>
<td>Opportunistic, incremental</td>
<td>Desconflicted with strategic goals</td>
</tr>
</tbody>
</table>
Continuous Nature of Sensemaking
Analytical Issues

- **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