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A Proposed Theoretical Foundation for the Information Systems Discipline (version 1. 1)

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"Rethink the theoretical foundations of the IS discipline" is one of the grand challenges for IS research identified in a Delphi study in *Business Information Systems Engineering* (Becker et al., 2015). This draft addresses that challenge directly through an integrated approach to the operation and evolution of systems. Almost any attempt to articulate a theoretical foundation for IS (a TFIS) would need to cover that topic although other attempts might emphasize other topics and other viewpoints.

Version 1.0 went to colleagues who provided early feedback at conferences or at university visits. It also went to co-authors and others who might find it useful. Feel free to forward the current version to anyone who might be interested.

This document is long – 50 pages – but it is designed like a slide presentation (one main idea on many pages, many diagrams, and use of bullet points for brevity) to allow relatively quick understanding of the overall approach and of how and why separate parts fit together as an integrated whole.

Quick scan. The outline on page 3 summarizes how the main ideas are organized. Scrolling page by page provides a deeper overview in the sequence of headings and figures or tables. Concise bullet points identify key insights or issues. Integration is based on consistent use of a work system perspective that is summarized briefly. Many pages are understandable independent of surrounding pages.

Deeper consideration. You might find value in deeper consideration of how some of this paper's ideas are related to your research interests, such as relevant ideas that you had not considered. Your insights about limitations of this approach might help in identifying future directions for your research.

Goals. The proposed Theoretical Foundation for IS (TFIS) has three main goals:

1) **Integration.** Build outward from an integrated core. Do not accept the excuse that the IS field is not ready for a serious attempt at integration.
2) **Usefulness.** Contribute to describing, analyzing, designing, and evaluating systems, developing new tools and methods, and supporting empirical IS research.
3) **Near-symmetry.** Treat sociotechnical systems (with human participants) and totally automated systems as similarly as possible. Trends toward digitalization, automation, AI, and robotics imply benefits from that type of near-symmetry for understanding changes in the "division of labor."

I hope you have time to consider whether this overall approach is plausible and might have useful implications for your research or teaching.

I would appreciate any comments you might have even though I recognize that many who see this are too busy to spend time on it. Again, feel free to forward this DRAFT to anyone who might be interested.

Thanks for your interest.

A Grand Challenge for IS

Bus Inf Syst Eng 57(6):377–390 (2015)
DOI 10.1007/s12599-015-0394-0

RESEARCH NOTES

In Search of Information Systems (Grand) Challenges

A Community of Inquirers Perspective

Jörg Becker · Jan vom Brocke · Marcel Heddier · Stefan Seidel

Table 3 Impact ("The solution of this issue will have a strong impact on the information systems discipline")

Rank	Challenges of IS research
1	C16 – leveraging knowledge from data, with the related management of high data volumes
2	C15 – integrating human and machine problem solving
3	C04 – rethink the theoretical foundations of the IS discipline
4	C03 – proving relevance of IS research
5	C06 – mastering the methodological breadth/richness

Table 5 Yes/no ("Overall, do you think that the issue above is a grand challenge for IS research?")

Rank	Challenges of IS research
1	C04 – rethink the theoretical foundations of the IS discipline
2	C16 – leveraging knowledge from data, with the related management of high data volumes
3	C03 – proving relevance of IS research
4	C15 – integrating human and machine problem solving

Introducing a Theoretical Foundation for IS: Approach and Organization

Version 1.1 uses the following approach:

1) **Explicit identification of an integrated core and a theoretical foundation**. Summarize an integrated core of ideas briefly and expand outward to demonstrate the theoretical foundation.
2) **Focus on ideas, not academic packaging**. Maintain focus by deferring discussions of motivation, related literature, methodology, and hundreds of references to documents listed on the last page.
3) **Sufficient detail**. Combine careful organization with enough detail to provide an intuitive feeling for possible applications, improvements, and extensions of the ideas.
4) **More examples, less verbiage**. Emphasize intuitive understanding of the approach by providing numerous figures and tables organized around a conceptual core. Except for the conceptual core, it is possible to visualize most of this approach by glancing at headings, figures, and tables throughout this document. Each page could be explained in much more detail.

The following outline and the design of this document try to make it as easy as possible to see how a TFIS can be constructed based on a work system perspective. (Comments in this shaded format appear throughout to highlight key points and to make it easy to follow the sequence shown below.)

- Work system perspective (summary)
  - Work system theory (WST)
  - Sociotechnical vs. totally automated work systems
  - Information systems and projects as work systems
  - Planned and unplanned change

- Proposed Theoretical Foundation of IS discipline (TFIS)
  1. Justification: rationale for proposed TFIS
  2. Coverage: domain and omissions
  3. Focal points: primary entity types, special cases, facets, portrayals, functions, overlaps
  4. Attributes of entities: characteristics, performance variables, phenomena
  5. Change: events, trajectories of change, forces, interactions
  6. Generalizations (building on WST): axioms, design principles, theories, frameworks, models, metamodels, methods

- Use cases
  - Analyzing and designing IT-enabled systems (work system method and toolkit)
  - Understanding topics in context: e.g., IS user satisfaction, IS security, AI, enterprise systems, outsourcing and platforms, conceptual links with other disciplines, etc.

- Conclusion
  - Tentative evaluation
  - TFIS summarized as a 3-page table
  - References (treated as endnotes from earlier pages).

Work System Perspective

Visualizing the Work System Perspective

[1,2, 3]

- Not just technologies. "System should not be a synonym of "technology used.". At minimum, viewing systems as objects that are "used" downplays the system properties of those things.

- Taking systems seriously. The work system perspective is based on thinking of systems as work systems. Figure 1 says that its core is work system theory. WST is a basis for defining different types of work systems; it organizes many WS attributes; and it leads to WST extensions whose additional ideas support deeper views of work systems. It has many use cases. It grew out of the evolution of its main use case, the work system method (WSM).

- Other possible starting points for visualizing systems will not be discussed here. These include general systems theory, sociotechnical systems theory, the Bunge-Weber-Wand (BWW) ontology, soft system methodology, activity theory, the viable system model, and so on.

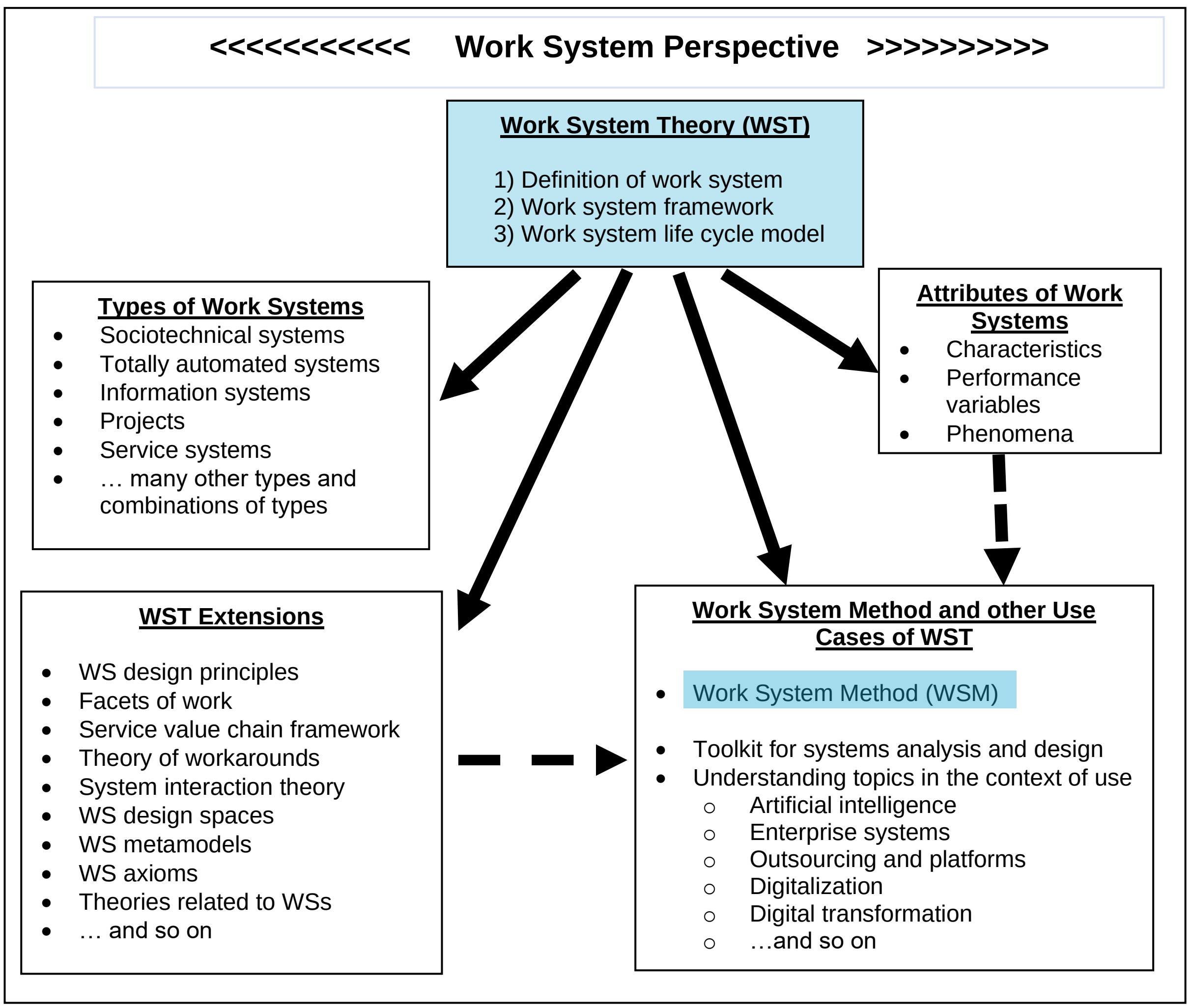


Figure 1. The work system perspective

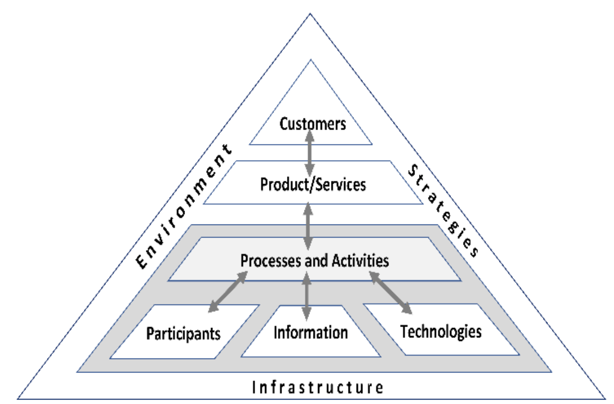
Work System Perspective

Building on Three Components of Work System Theory

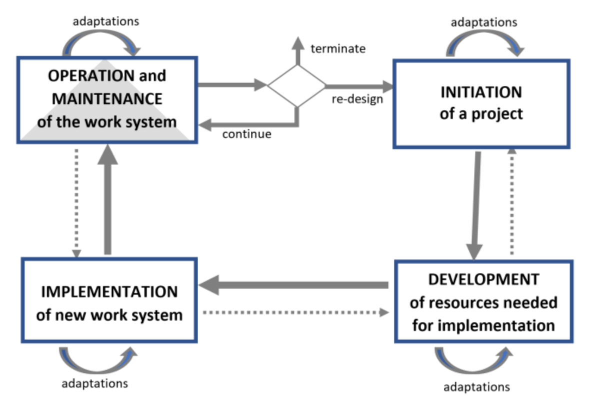
Three components of WST apply equally to information systems, a type of WS:

- The definition of WS
- The work system framework: nine elements of a basic understanding of a WS's form, function, and environment during a period when it is stable enough to retain its identity even though incremental changes may occur, such as minor process changes, personnel substitutions, or technology upgrades.
- The work system life cycle model (WSLC): how a work system evolves iteratively through planned and unplanned change.

Definition of work system. A system in which human participants *and/or* machines perform work (processes and activities) using information, technology, and other resources to produce specific product/services for internal and/or external customers.



Work System Framework



Work System Life Cycle Model (WSLC)

Figure 2. Three components of work system theory

Examples of work systems (identified by MBA students who produced management briefings)

• Deciding premium rates for insurance renewals • Receiving materials at a large warehouse • Controlling marketing expenses • Approving real estate loans • Purchasing advertising services • Finding new clients of a consulting firm	• Planning and dispatching trucking services • Scheduling and tracking health service appointments • Operating an engineering call center • Collecting and reporting sales data for a wholesaler • Performing financial planning for wealthy individuals • Invoicing for construction work	• Determining government incentives for providing employee training • Planning for preventive maintenance of key real time information systems • Acknowledging gifts at a high-profile charity • Performing pre-employment background checks • Administering grant budgets

Work System Perspective

Visualizing a Work System: Elements of a Basic Understanding

The work system framework identifies 9 elements of a basic understanding of a work system.

- *Processes and activities*, *participants, information*, and *technologies* are treated as though they are completely within the WS (or IS).
- *Customers* and *product/services* may be partially inside and partially outside, e.g., customer participation in many service activities.
- *Environment, infrastructure*, and *strategies* are viewed as outside of the WS (or IS) even though they may have strong impacts on WS operation.

(For convenience, the nine elements are called WS elements even though they actually are elements of an understanding of a WS - some of which are not part of the WS).

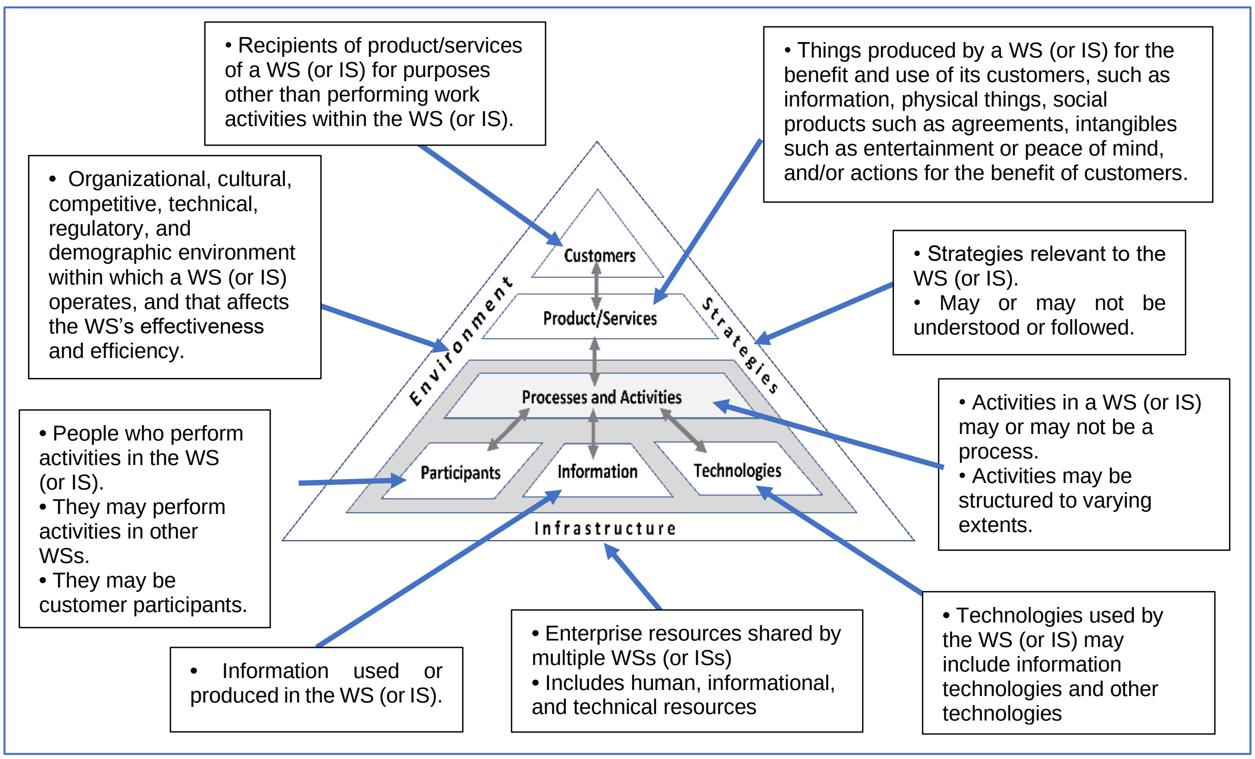


Figure 3. Elements of the work system framework

Work System Perspective

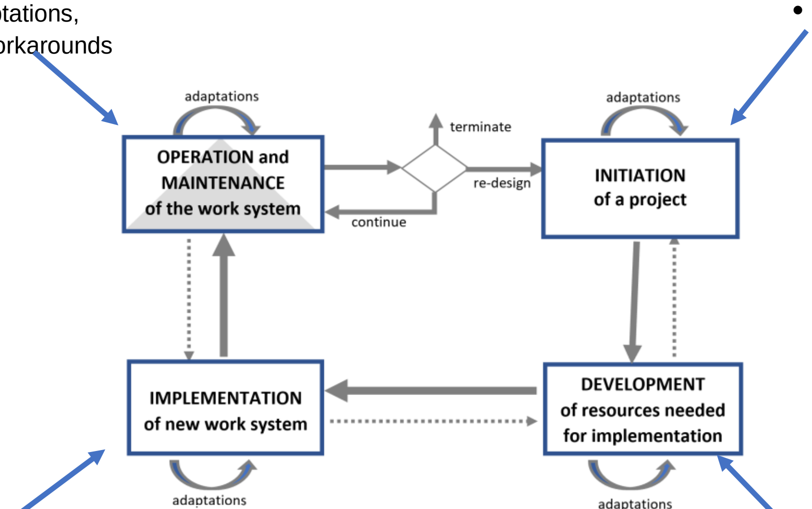
Fulfilling Responsibilities as Work Systems Evolve over Time

Work system life cycle model (WSLC). Figure 4 describes the evolution of a WS, which may involve iterations through its four phases.

- Typical activities and responsibilities for the WSLC phases apply for waterfall, agile, prototyping, use of off-the-shelf applications, shadow IT, etc.
- The typical activities and responsibilities apply even when several phases overlap or are combined through short iterations, e.g., quick cycles of software improvement, implementation, feedback, and further improvement.
- While relevant to different development approaches, the WSLC itself describes the evolution of a WS, which may involve many iterations of the four phases.

- Produce product/services,
- Track performance,
- Identify exceptions,
- Make adaptations,
- Perform workarounds

- Define vision,
- Allocate resources,
- Produce plan,
- Assess feasibility



- Determine change management approach,
- Produce implementation plan,
- Test changes,
- Identify implementation issues and learnings,
- Train work system participants,
- Convert to new work system

- Determine requirements,
- Design work system,
- Acquire or modify, software/hardware,
- Debug,
- Test,
- Produce documentation,
- Produce training materials

Figure 4. Typical activities and responsibilities associated with each phase of the WSLC

Work System Perspective

Defining Information Systems as Work Systems

- **Definition**: An IS is a WS most of whose activities are devoted to processing information, i.e., capturing, storing, retrieving, deleting, transmitting, manipulating, and displaying information.
- Seeing ISs as WSs is a step toward an integrated view of the various types of systems and projects within the IS discipline.

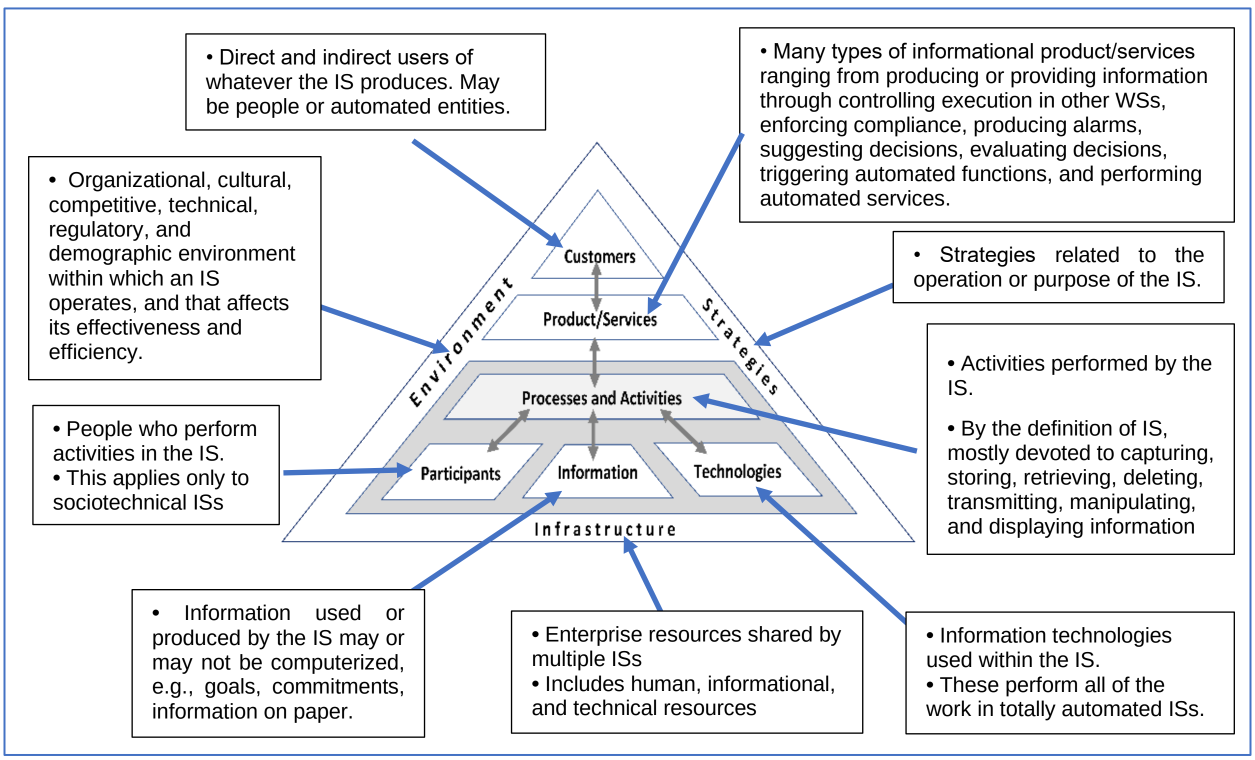


Figure 5. Defining information systems as work systems

Work System Perspective

Seeing IS Development as a Work System

- Seeing IS development as a (project-oriented) work system is a further step toward an integrated view of the various types of systems and projects within the IS discipline.

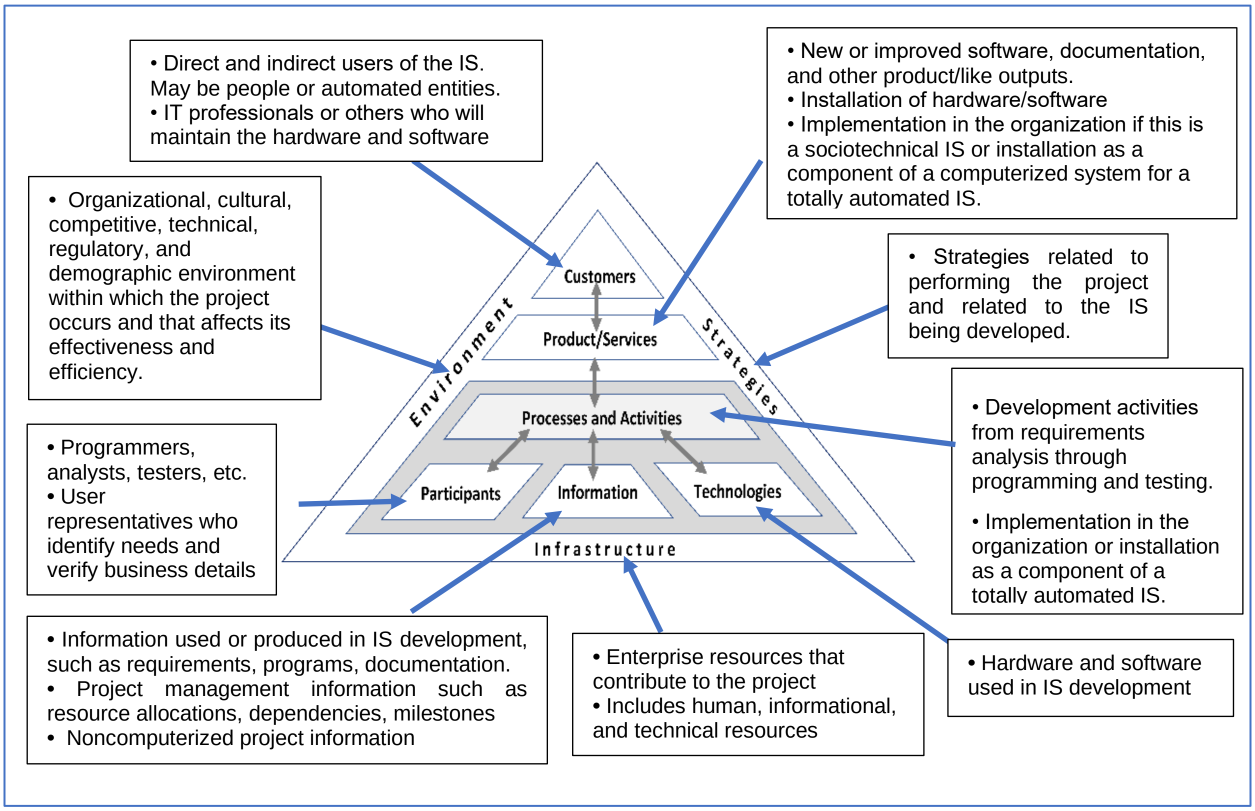


Figure 6. Seeing information system development as a work system

Work System Perspective

Recognizing Planned Change and Unplanned Change

- The WSLC recognizes that WS evolution often involves both planned and unplanned change regardless of whether waterfall, agile, prototyping, off-the-shelf applications, shadow IT, or other development approaches are used.
- Planned change occurs through formal projects that perform activities associated with the initiation, development, and implementation phases.
- Unplanned change occurs through adaptations and workarounds, often in the operation and maintenance phase.

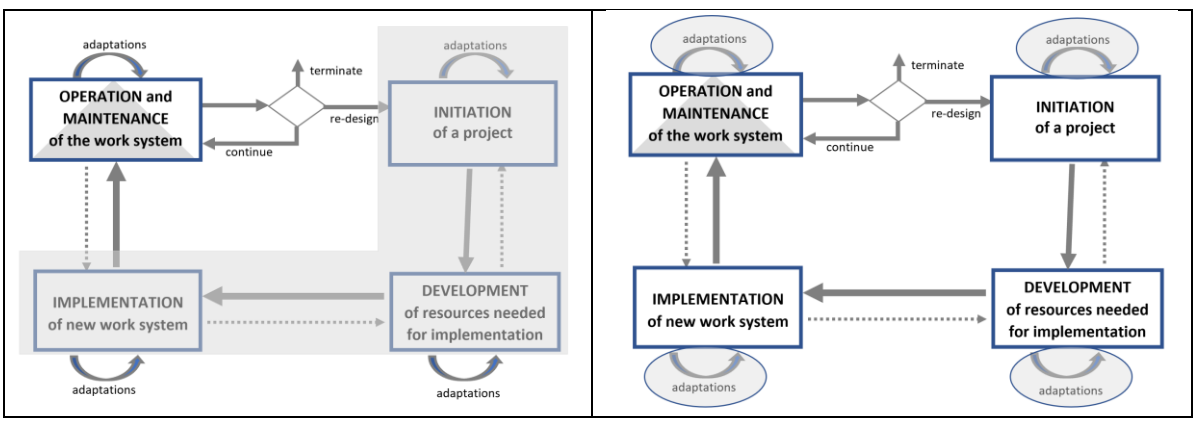


Figure 7. Planned change and unplanned change in the WSLC

TFIS 1: Justification

Imagining the Work System Perspective as a Theoretical Foundation for IS [4,5,6,7,8,9]

- The TFIS integrates most of the system-related topics in the IS discipline.

- The core subject matter of the IS field involves IT-enabled work systems in organizations.
- IS is a special case of WS. ISs are WSs most of whose processes and activities are devoted to capturing, storing, retrieving, deleting, transmitting, manipulating, and/or displaying information.
- IS development is a type of project. Projects are WSs that are designed to produce specific product/services and then go out of existence.
- ISs, projects, and other relevant special cases of WS inherit many of the concepts and generalizations related to work systems in general. In this context, generalizations include axioms, design principles, theories, frameworks, models, metamodels, and methods and other ideas that describe or apply to multiple instances within the domain of WSs.
- Some supply chains and ecosystems can be viewed from a work system perspective by recognizing that work systems can extend across enterprises. This may help in analyzing outsourcing, use of platforms, and many types of service that perform essential roles in work systems.
- WST is designed to treat sociotechnical work systems and totally automated work systems as symmetrically as possible. This is useful in light of strong trends toward assigning activities and responsibilities to totally automated systems and subsystems when creating new work systems and redesigning existing work systems.

TFIS 2: Coverage

Bounding the Proposed Theoretical Foundation and Recognizing its Omissions [10,11,12]

- **Domain.** The TFIS includes sociotechnical WSs (with human participants) and totally automated WSs (without human participants) that perform work autonomously.

- The TFIS tries to treat sociotechnical systems and totally automated systems as symmetrically as possible to help in understanding changes and trends involving increasing automation of work that have been performed by people and new types of processes that cannot be performed by people.

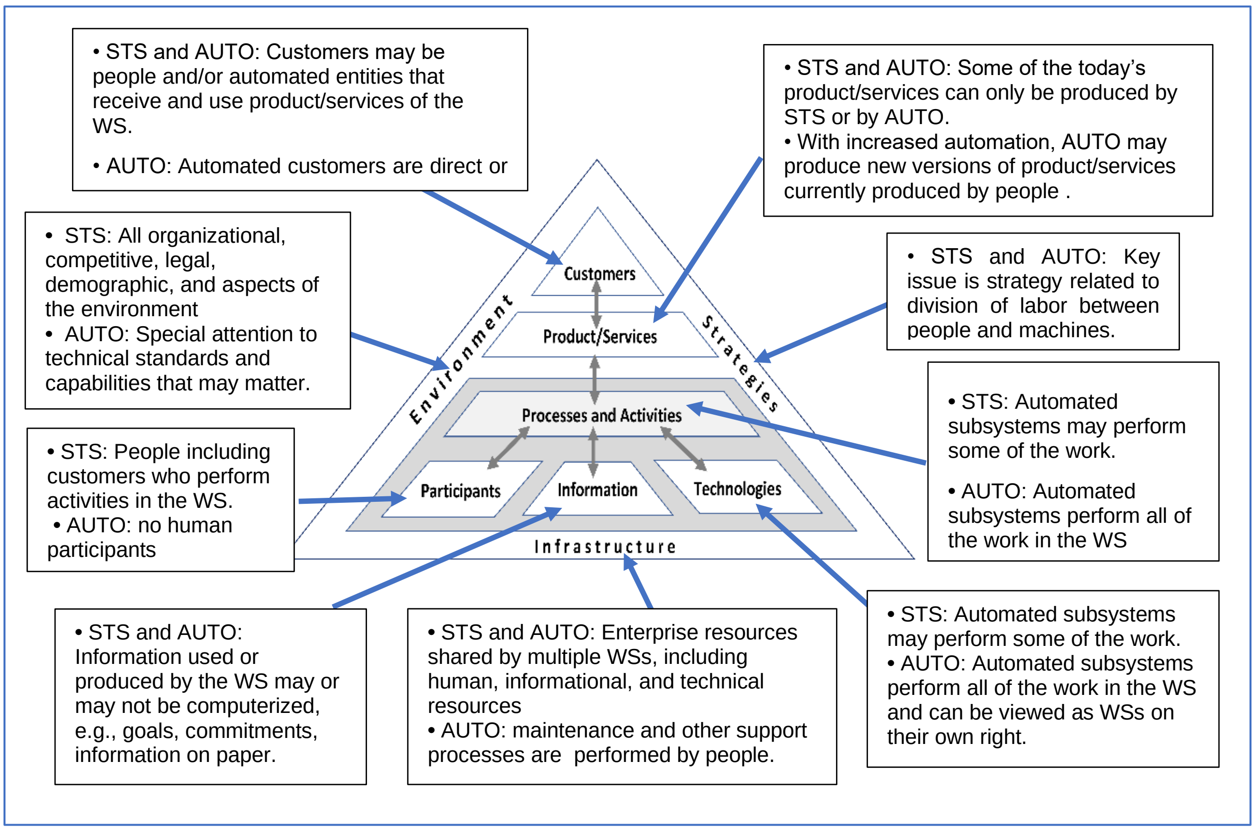


Figure 8. Comparing sociotechnical work systems (STS) and totally automated work systems (AUTO)

- **Omissions**: Important topics outside the main emphasis of the TFIS include IS/IT organizations, IS/IT careers, the IT productivity paradox, aggregate business value of IT, uses of IT for individual amusement, changes in organizational culture, the nature of competition, the digital divide, and physiological, motivational, psychological, and ethics-related topics covered by most directly by other disciplines.

TFIS 3:
Focal Points

Identifying Primary Entity Types and Their Special Cases

- The primary entity types are work systems.
- After the first layer (sociotechnical WS vs. totally automated WS) various special cases of WS are described for different purposes. Special cases may overlap and do not exist in a single top to bottom hierarchy.
- Special cases related to IS inherit concepts and other knowledge from more general cases and can have their own special cases, such as totally automated ISs based on machine learning or (sociotechnical) projects that produce customized software. All of the following are examples that inherit ideas from WS in general and have additional inheritance relations.
  - *Sociotechnical IS* inherits concepts and knowledge from *sociotechnical WS.*
  - *IS project* inherits concepts and knowledge from *project.*
  - *Software development project* inherits concepts and knowledge from *project.*
  - *Open-source software development project* inherits concepts and knowledge from *software development project*.
- Some special cases (such as totally automated project) may not exist today but point to directions for the future.

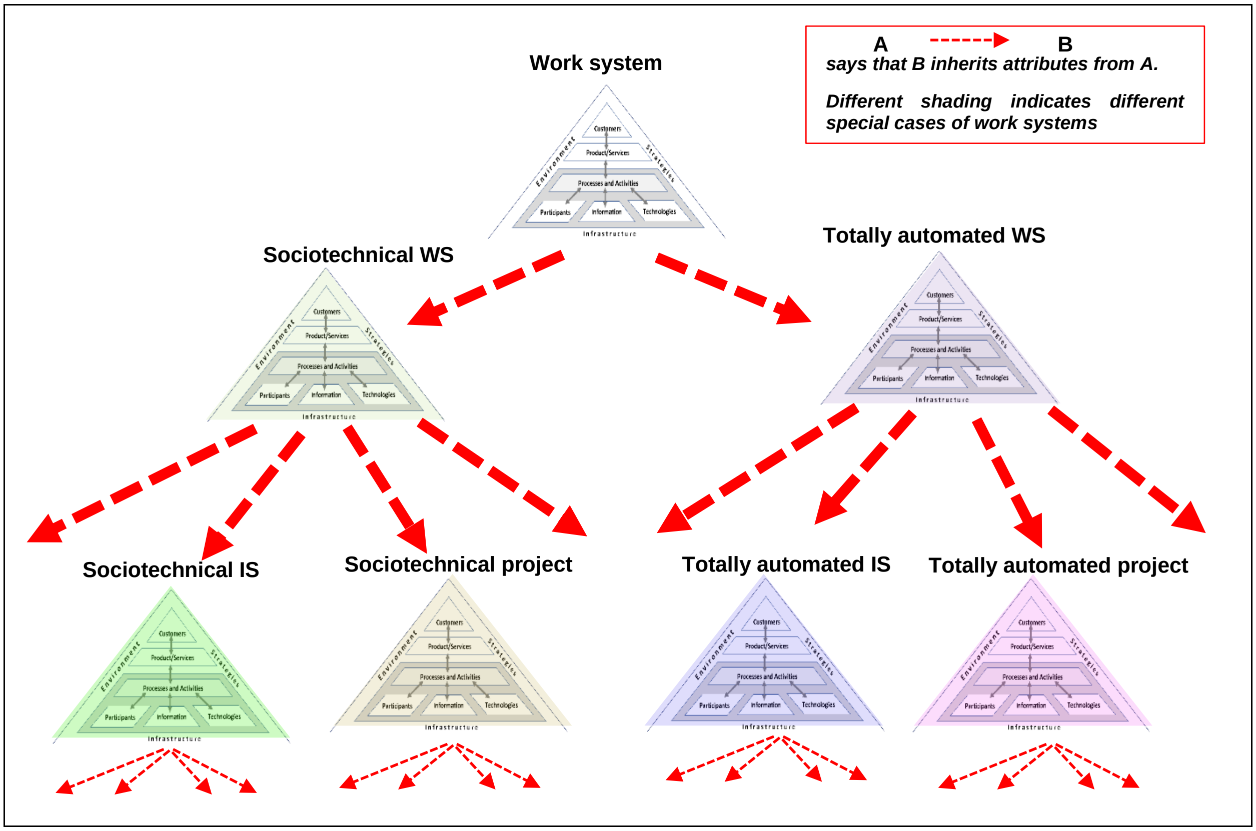


Figure 9. WS special cases and inheritance of attributes

TFIS 3:
Focal Points

Recognizing Common Facets of Work [13,14]

- Attempts to describe or analyze entire WSs and specific WS elements often need to consider different aspects of a WS or of a WS element, analogous to the multiple facets of a cut diamond.
- Facets of work represent a large body of practical knowledge and research knowledge related to processes and activities that is barely mentioned in SA&D methods.
- The following 18 facets of work were developed through an iterative process. Other researchers might have identified 15 or 23 facets. The main point is to provide an organized approach for looking at important generic aspects of activities or groups of activities.

18 "Facets of Work" all related to *Processes and Activities* in the Work System Framework

• Making decisions	• Applying knowledge	• Performing physical work
• Communicating	• Learning	• Performing support work
• Processing information	• Planning	• Interacting socially
• Thinking	• Controlling execution	• Providing service
• Representing reality	• Improvising	• Creating value
• Providing information	• Coordinating	• Maintaining security

- **Criteria.** All 18 facets of work satisfy criteria related to broad usefulness. All are easily understood, widely applicable, and associated with concepts and knowledge related to business situations. All apply to both sociotechnical systems and totally automated systems; all are associated with many concepts that can be used for analyzing WSs; all are associated with evaluation criteria and typical trade-offs; all have sub-facets that can be discussed; all bring open-ended questions that are useful for starting conversations and that might be used for deeper analysis. Most facets are not mutually independent. E.g., making decisions often involves communicating, processing information, and thinking.

The following table shows knowledge related to *making decisions*, one of the 18 facets of work.
A similar table can be produced for the other 17 facets.

Associated concepts	Decision, criteria, alternative, value, risk, payoff, utility, utility function, tradeoff, projection, optimum, satisficing vs. optimizing, heuristic, probability, distribution of results, risk aversion
Evaluation criteria	Actual decision outcomes, realism of projected decision outcomes, riskiness, decision participation, concurrence, ease of implementation
Design trade-offs	Quick responsiveness vs. superficiality, complexity and precision of models vs. understandability, brevity vs. omission of important details
Sub-facets	Defining the problem; identifying decision criteria; gathering relevant information; analyzing the information; defining alternatives; selecting among alternatives; explaining the decision
Open-ended questions	Open-ended question: How do the available methods and information help in making important decisions? ... Follow-on questions: What decisions are made with incomplete, inaccurate, or outdated methods or information? How might better methods or information help in making decisions? Where would that information come from?

TFIS 3:
Focal Points

Expanding Facets of Work into Facets of Work System Elements

- The idea of facets of work can be extended to facets of work systems. Figure 10 identifies facets that apply to work systems as a whole and to individual WS elements. The original 18 facets of work are the facets included for *processes and activities*.

- Some of the criteria satisfied by the facets of work are not satisfied by some of the facets of work system elements in Figure 10.

- Identification of these WS facets is a reminder that many discussions related to specific WSs or elements of WSs or ISs focus on only a small number of facets and ignore many of the others that might be relevant.

- The various responsibilities in each phase of the work system life cycle (Figure 4) are activities that could be viewed as facets of those phases. They are not listed as facets because it is more valuable to think of them as responsibilities.

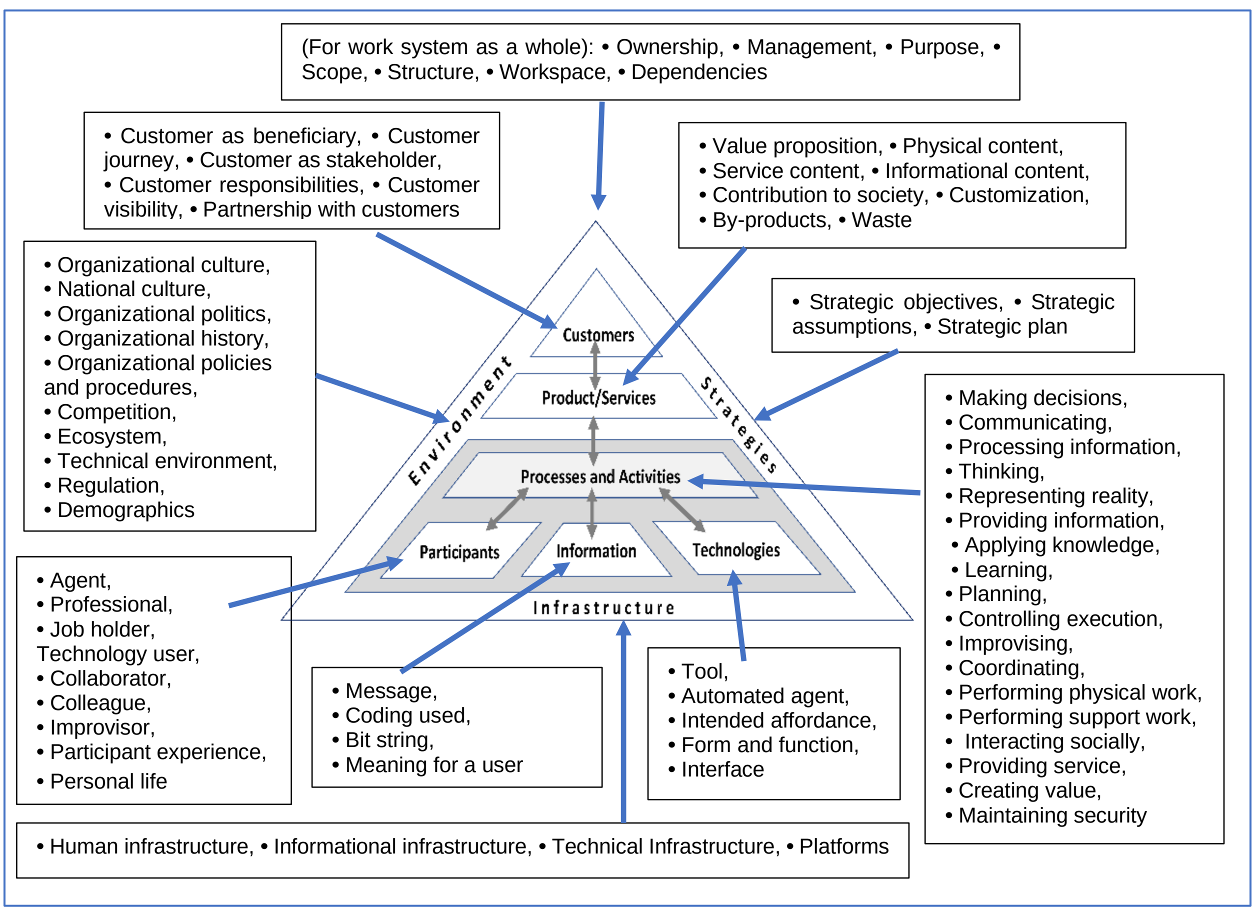


Figure 10. Facets of work systems

TFIS 3: Focal Points

Recognizing Alternative Portrayals of Work Systems and Work System Elements [15]

- The TFIS treats portrayals as generic views of entire WSs (or ISs) or of specific WS elements. Different portrayals of a WS or WS element are often useful for different purposes. Alternative portrayals differ from facets, which are different generic aspects (partial views) of entire WSs or WS elements. Figure 11 identifies multiple portrayals of WSs and WS elements.

- **A cause of confused communication**. Unidentified use of different portrayals of the same thing or phenomenon in IS practice and in IS research causes confused communication and may lead to design errors or omissions. Common examples in IS research publications involve literature citations that inadvertently combine inconsistent or unrelated portrayals of system, IS, usage, service, and other common terms.

- Treating alternative portrayals as legitimate sometimes conflicts with common assumptions that concepts should have a single, precise definition. Those assumptions are beneficial for modeling but often are inconsistent with everyday usage of many ideas.

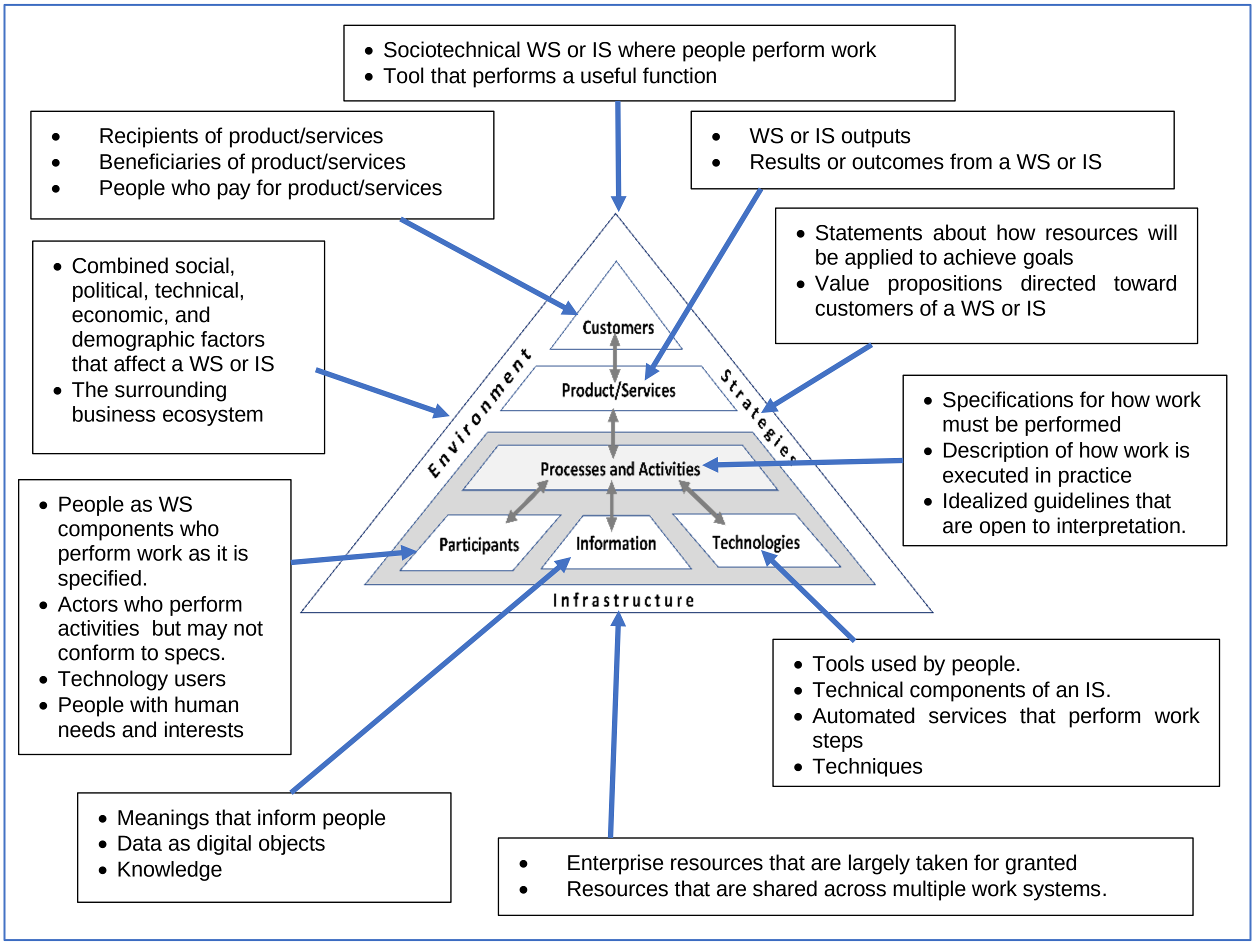
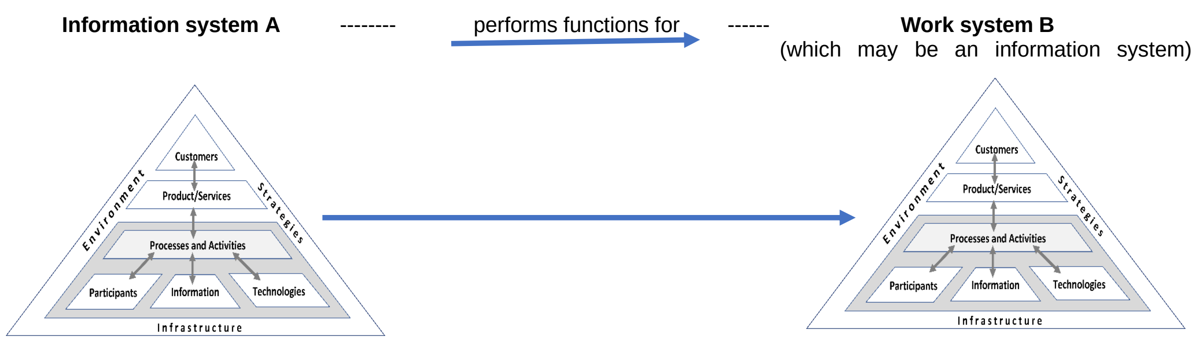


Figure 11. Alternative portrayals of work systems and work system elements

<table><tr><td>TFIS 3:
Focal Points</td></tr></table>

Highlighting Different Types of Functions Performed by Information Systems

- ISs may perform a variety of functions that contribute to the operation of WSs that they support, some of which may be ISs on their own right.
- A complete understanding of a specific IS in an organizational setting calls for identifying functions that it performs, assessing how well it performs those functions, identifying other functions that it should perform, and identifying beneficial changes that are cost-effective.
- The fact that ISs may perform many types of functions for other WSs demonstrates a major limitation of thinking of ISs as tools that are used by users, as entities that process information, or as representations of real-world situations.
- In the current context, the term *role* might have been used instead of *function*. Function is used because role is often associated with responsibilities of individual WS participants.



Examples of functions that an IS might perform for another WS

- providing access to information,
- defining and enforcing rules for collecting or sharing information,
- providing methods for aggregating information,
- providing methods for analyzing information,
- controlling the sequence of activities in workflows,
- enforcing compliance with business rules,
- producing alarms when predefined conditions occur,
- controlling or facilitating coordination,
- suggesting or evaluating decisions,
- triggering automated functions,
- performing automated tasks.

Figure 12. Functions performed by information systems

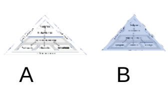
TFIS 3:
Focal Points

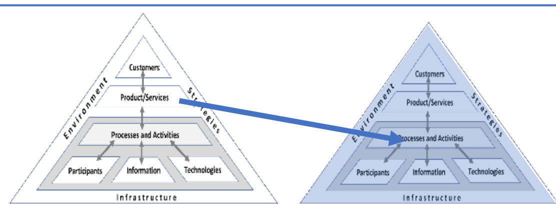
Recognizing Different Forms of Overlap between Work Systems [1]

- WSs (including ISs) often overlap with other WSs (including ISs) that play important roles in their operation, as when ISs support or serve as components of other WSs that may or may not be ISs.

- Figure 13 uses simplified examples to illustrate different forms of overlap ranging from interaction via a simple interface through complete enclosure of one WS by another.

- When the overlap is only a simple interface, the design question at hand is to make the interface simple and convenient. Design issues in the other cases are more difficult, especially when people have simultaneous responsibilities in separate WSs or ISs. A prime example is the use of electronic medical record systems, which have increased burnout in primary care physicians who participate simultaneously in two WSs as they go back and forth between treating patients, finding data in EMRs, and entering data into EMRs in a limited amount of time.



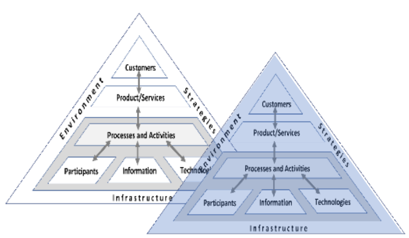


Interaction through a simple interface.

Example: Using an ATM

A = ATM owner's WS of maintaining and stocking the ATM

B= ATM user's WS of finding the ATM and interacting with it to obtain cash

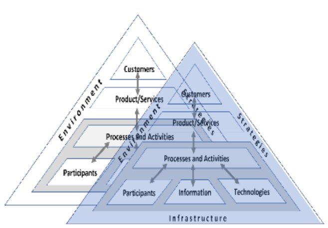


Separation or minimal overlap

Example: Use of a travel reservation web site

A = web site's automated WS of updating price and availability data, answering queries, and performing and recording transactions

B = user's WS of searching for a good tradeoff between cost and convenience



Substantial overlap

Example: Physician's use of an electronic medical record system (EMR) for obtaining and recording data.

A = EMR WS that serves multiple medical functions and therefore does much more than answering queries and storing data for physicians

B = physician's WS of providing medical care

Enclosure

Example: Periodic financial closing at a firm.

A = totally automated IS that generates accounting reports

B = sociotechnical accounting IS for making accounting decisions and producing financial statements

Figure 13. Overlaps between information systems and work systems that they support

TFIS 4:
Attributes

Identifying Frequently Relevant Characteristics of Work Systems

- Describing and characterizing entire work systems and work system elements (not just documenting process logic and mechanical aspects of work system operation) is essential for understanding, analyzing, designing, and evaluating work systems.

- Figure 14 identifies many frequently relevant characteristics. Many other characteristics could have been included.

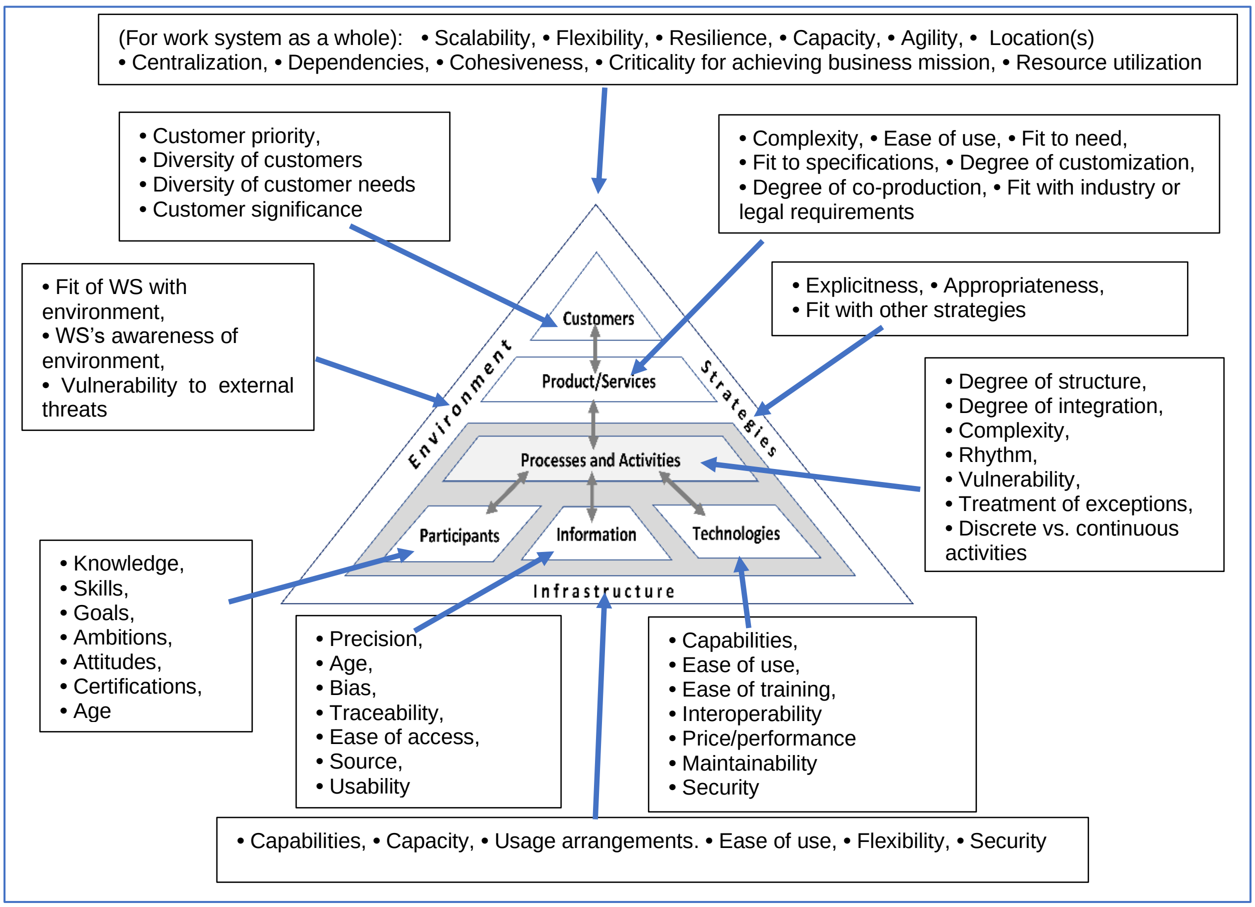


Figure 14. Commonly relevant characteristics of work systems and work system elements

TFIS 4: Attributes

Identifying Common Performance Variables for Work Systems

- Most real-world situations call for considering multiple performance variables for work systems as a whole and for work system elements.

- Figure 15 identifies many frequently relevant performance variables. Other frequently relevant performance variables could have been included. Most performance variables can be measured by using multiple metrics or performance indicators.

- **Goals.** The related concept of goal is an aspiration or requirement for a level of performance related to a specific metric. Goals are neither performance variables nor characteristics of work systems. Rather, they are joint attributes of decision makers who set goals and a WS or WS element that ideally should meet or exceed those goals. Since goals are joint attributes, in some situations new decision makers may change goals without changing anything about the details of a WS (or IS).

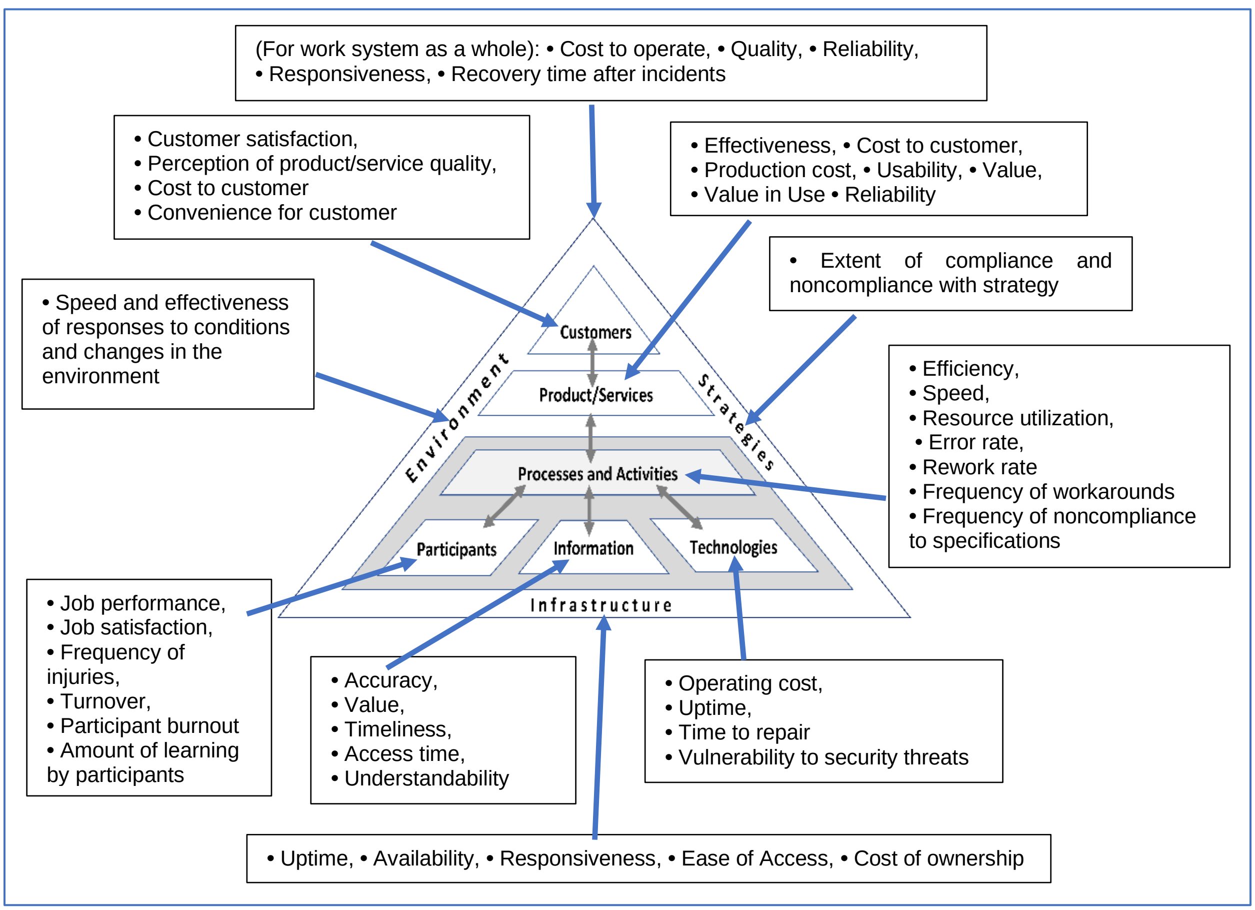


Figure 15. Common performance variables for work systems and work system elements

TFIS 4: Attributes

Identifying Important Phenomena Related to Work Systems

- Phenomena are perceptible circumstances or occurrences that have an impact or are otherwise noteworthy but that are not components of a WS's structure or operation and are not inherent characteristics or performance variables for a WS or its elements.
- Phenomena are often important research topics. Many other phenomena could have been included.

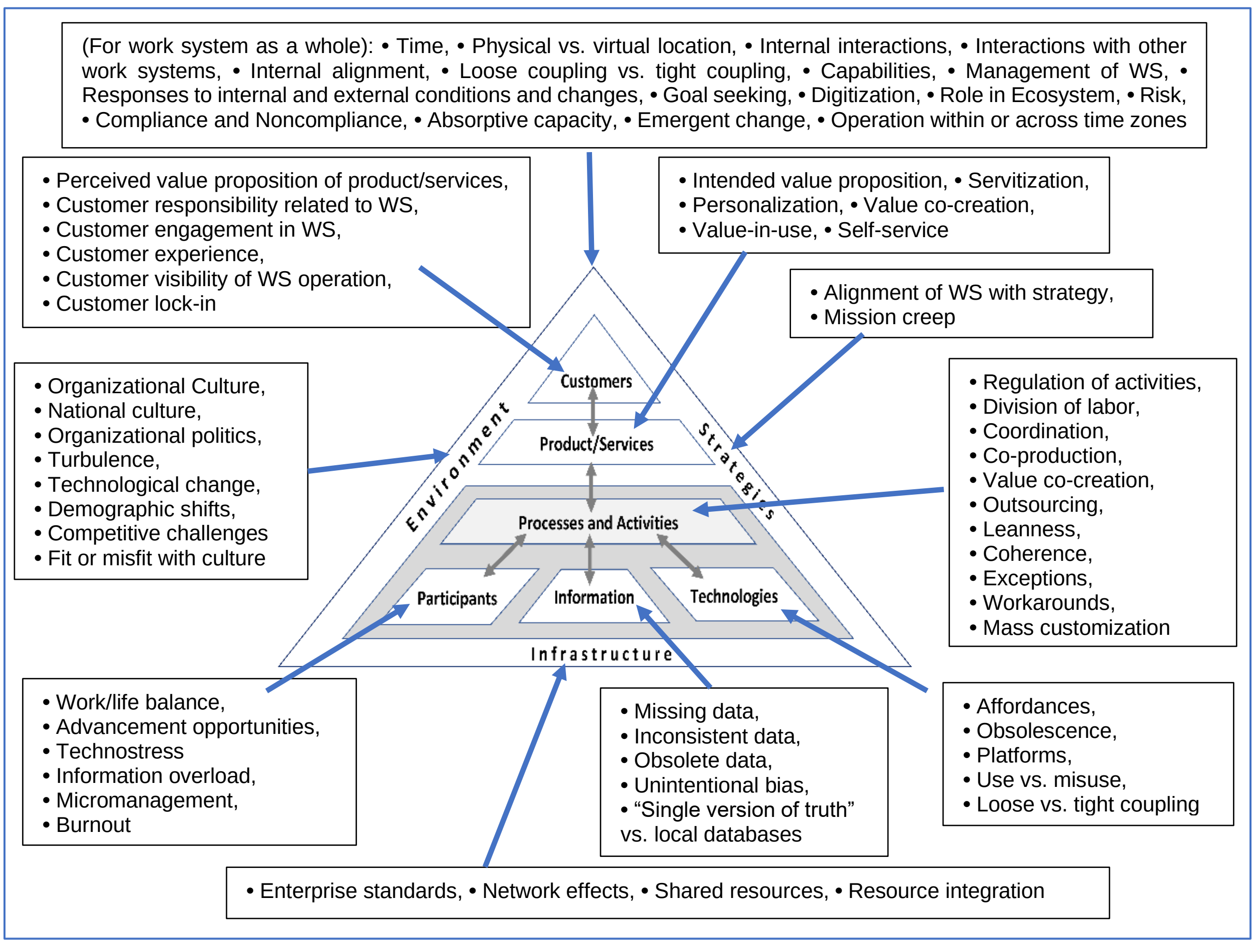


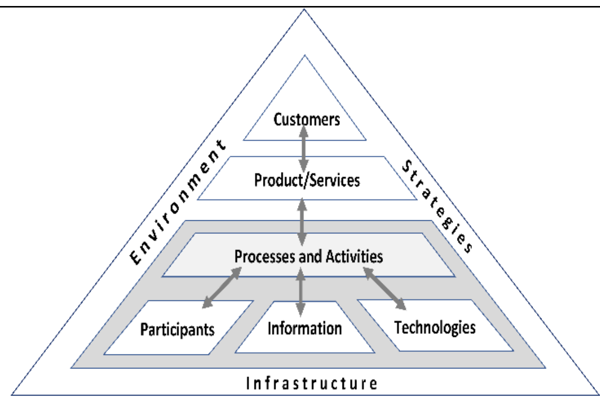
Figure 16. Phenomena related to work systems and work system elements

TFIS 5: Change

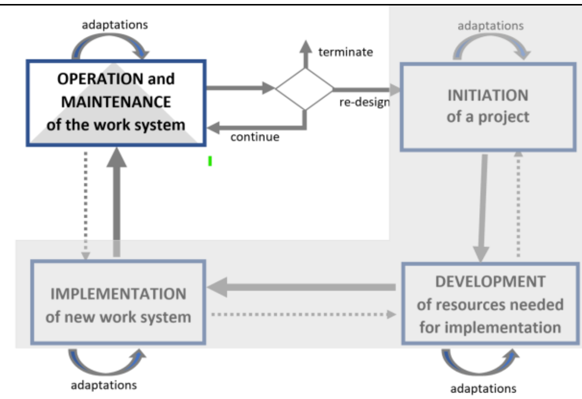
Recognizing Where Change Occurs in the Structure or Operational State of an IS

- Changes in the structure or operational state of an IS or IS element occur through different types of events and activities in Figure 17.

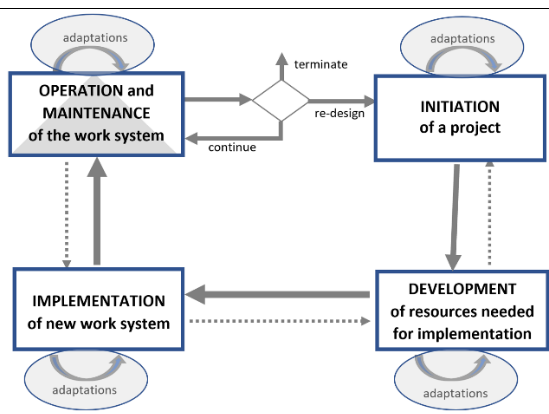
- Different focal points for analyzing IS-related changes will be discussed in the following pages:
    - ***Events*** include any noteworthy changes in the state of an IS or its elements or other resources.
    - **Trajectories of change** are organized sequences of events. These may be repetitive and formulaic or largely improvisational.
    - **Forces** influence the occurrence of events or trajectories of change.
    - ***Interactions*** between WSs often result in changes in the state of an IS and IS elements.



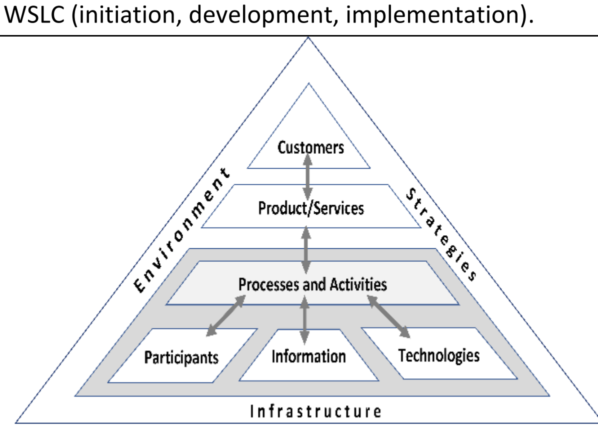
1. Processes and activities performed within the structure, capabilities, and purposes of one of more ISs or WSs that are the focus of attention



2. Activities that create or modify elements of an IS or WS during part of the planned change sequence in the WSLC (initiation, development, implementation).



3. Workarounds, adaptations, and other intentional activities within an IS or WS that may conflict with its structure, capabilities, or purposes.



4. Accidental or unintentional activities or events that may degrade, disable, or destroy IS or WS capabilities, but in other cases may enhance those capabilities.

Figure 17. Activities and events that change the structure or operational state of an IS

TFIS 5: Change

Visualizing How Workarounds Happen (A Trajectory of Change) [16,17]

- The WSLC accommodates both planned and unplanned change (previous page). Workarounds exemplify unplanned change that may affect any part of a work system, i.e., not just technology. The theory of workarounds in Figure 18 extends WST by explaining how workarounds occur.
- Workaround is defined as a "goal-driven adaptation, improvisation, or other change to one or more aspects of an existing WS in order to overcome, bypass, or minimize the impact of obstacles, exceptions, anomalies, mishaps, established practices, management expectations, or structural constraints that are perceived as preventing that WS or its participants from achieving a desired level of efficiency, effectiveness, or other organizational or personal goals."
- That definition recognizes that workarounds may represent beneficial noncompliance, which implies that failure to enact an appropriate workaround may represent detrimental compliance.

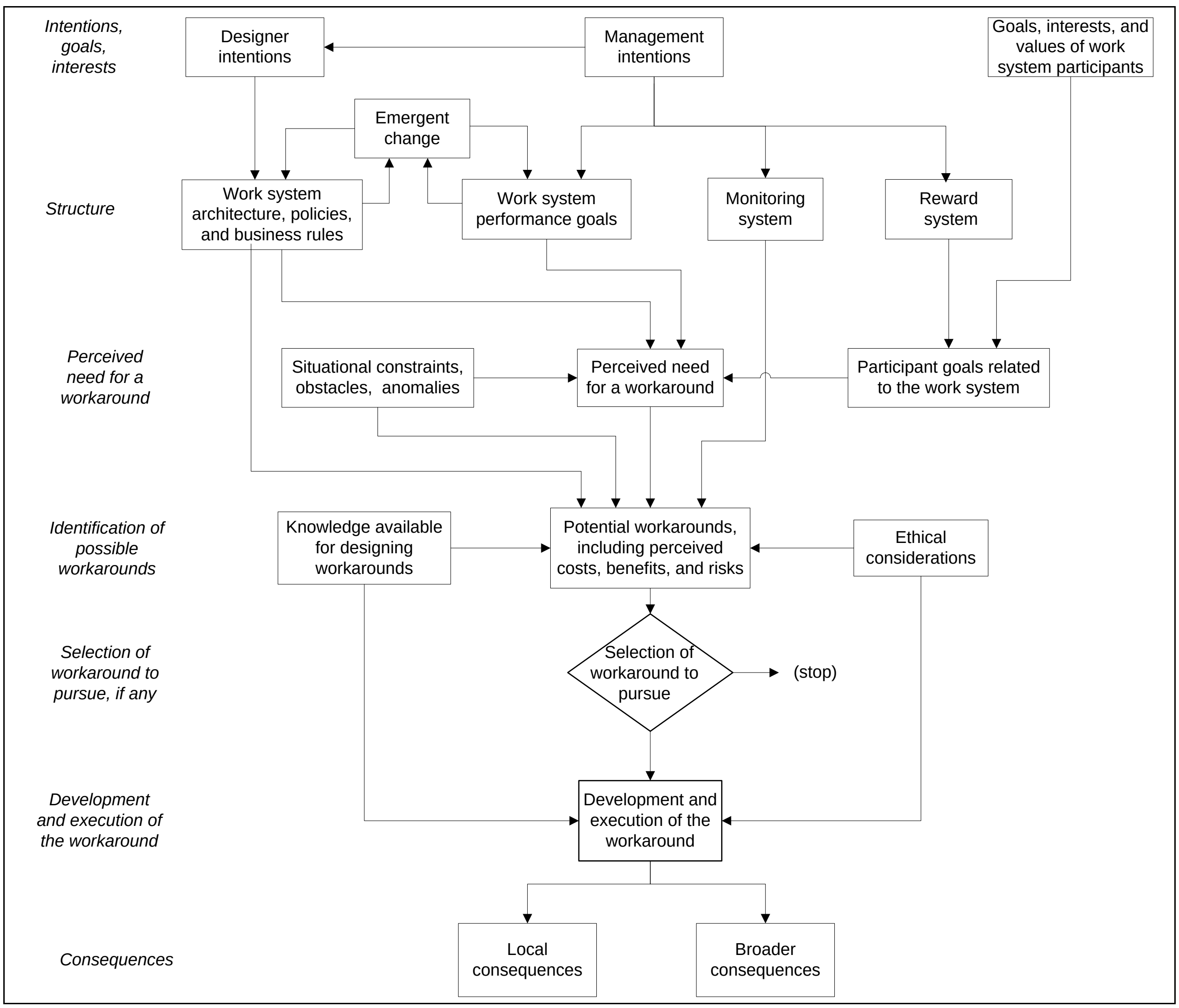


Figure 18. How workarounds happen (theory of workarounds)

TFIS 5: Change

Visualizing How Workarounds May Lead to Longer Term Change [16]

- Figure 19 builds on the theory of workarounds by introducing a time dimension and showing how workarounds can be a starting point for longer term changes.
- Improvisations may occur in the time frame of seconds-to-minutes. Bricolage, making do with whatever is available, includes improvisations but also extends to longer term incremental changes in routines.
- Eventually, both the success of bricolage and the issues that it cannot overcome lead to formal projects or informal projects (e.g., creating localized shadow IT systems) that attempt to generate longer lasting WS (or IS) improvements.

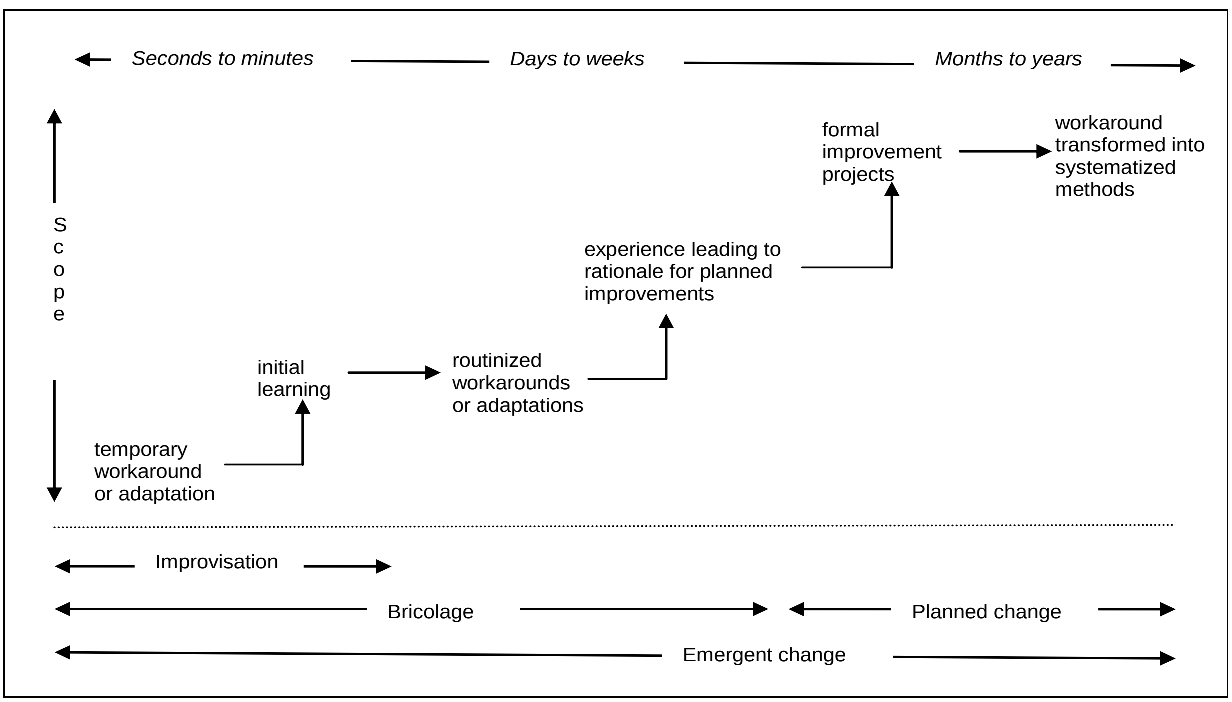


Figure 19. How workarounds may lead to longer term change

TFIS 5: Change

Identifying Forces that Encourage or Discourage Changes in in WSs (or ISs)

- The idea of forces appears throughout the physical and social sciences but is not discussed a great deal in relation to IS, where metaphors such as success factors, risk factors, and drivers vs. impediments to change are more common.
- Imagining analogies between forces in natural science and forces related to WSs and ISs led to the identification of five types of forces that each take many different forms.
- Consideration of these forces is potentially useful in creating a big picture view of how and why specific WSs and ISs change easily or resist change.

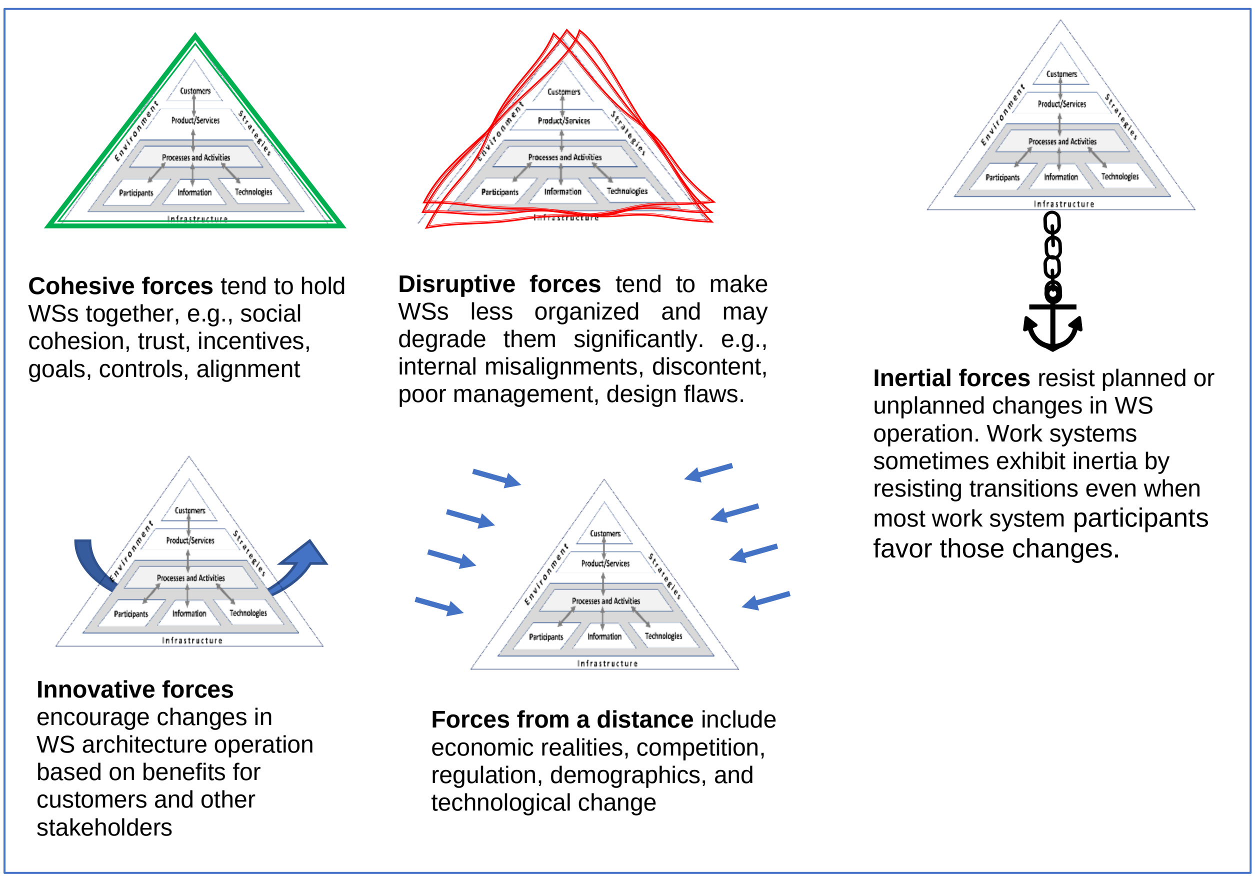


Figure 20. Forces that lead to change in work systems (including ISs)

TFIS 5: Change

Identifying Drivers and Impediments to Innovation and Change in WSs (or ISs) [18]

- Drivers and impediments of innovation are an important part of understanding how and why WSs and ISs change.
- The common idea of success factors and risk factors is a variation on the idea of drivers and impediments. The drivers and impediments in the figure below are related to individual elements of a WS rather than applying to WSs (ISs) as a whole like the forces on the previous page.
- The neutral form of each factor in Figure 21 implies that its adequacy or inadequacy could be a driver or impediment to innovation and change. For example, inadequacy of customer satisfaction tends to be a driver of change whereas adequacy of customer satisfaction tends to be an impediment to change.

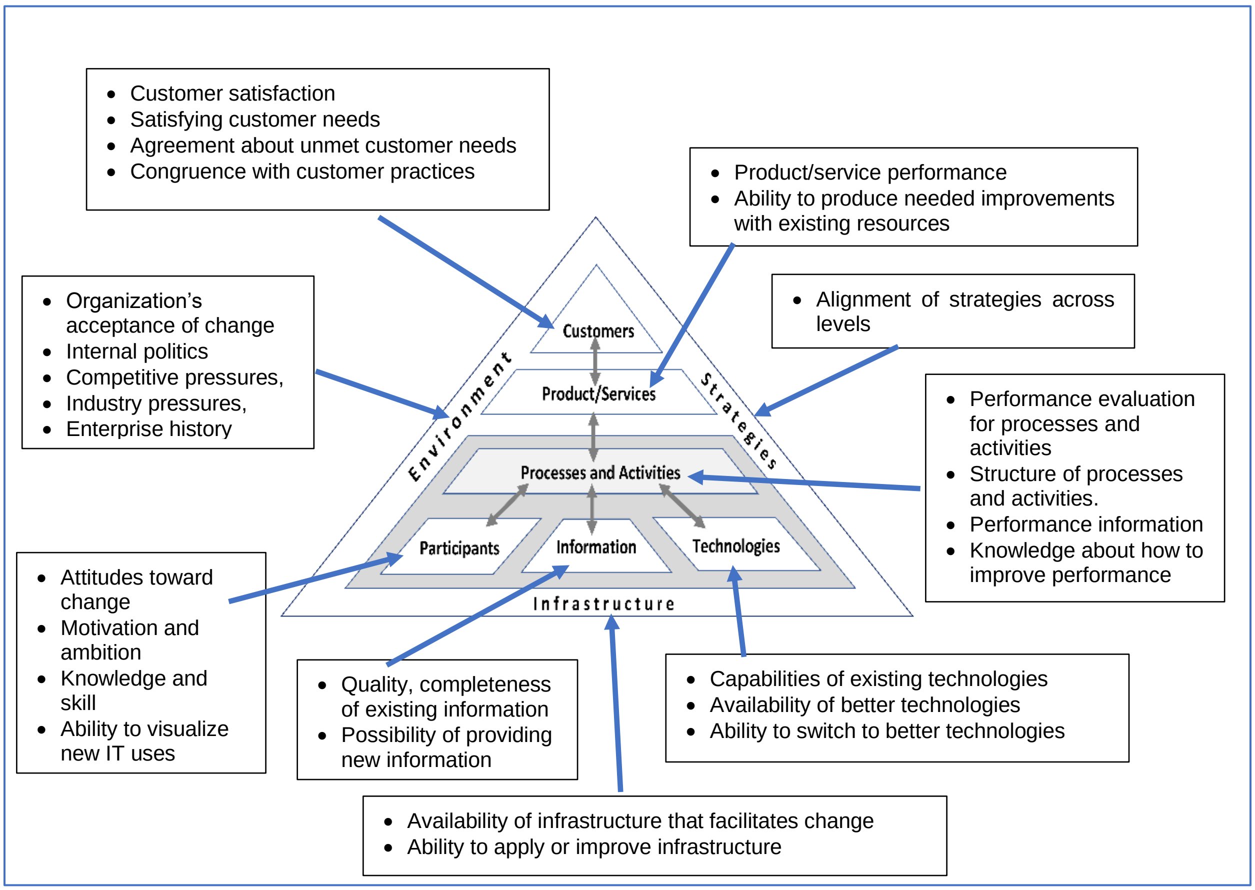


Figure 21. Factors whose adequacy or inadequacy can serve as a driver or impediment to change

TFIS 5: Change

Describing Work System Interactions [19,20]

- Interactions between WSs (or ISs) and between their sub-systems are essential for the operation of any enterprise, organization, or business ecosystem. Interactions also bring significant risks related to intentional and unintentional conditions or occurrences. System interactions also are an essential aspect of why and how WSs/ISs change.

- A system interaction is a specific occurrence, impact, or influence whereby one WS or IS affects another (a one-way interaction) or two or more systems affect one another (two-way or multi-directional interaction).

- Figure 22 summarizes "system interaction theory," which identifies key aspects of a basic understanding of WS or IS interactions that may be intentional or accidental. An icon for the work system framework appears twice in the figure to emphasize that system interactions in the TFIS are WS interactions. Each colored block has been described elsewhere in more depth, with special attention to related concepts or patterns.

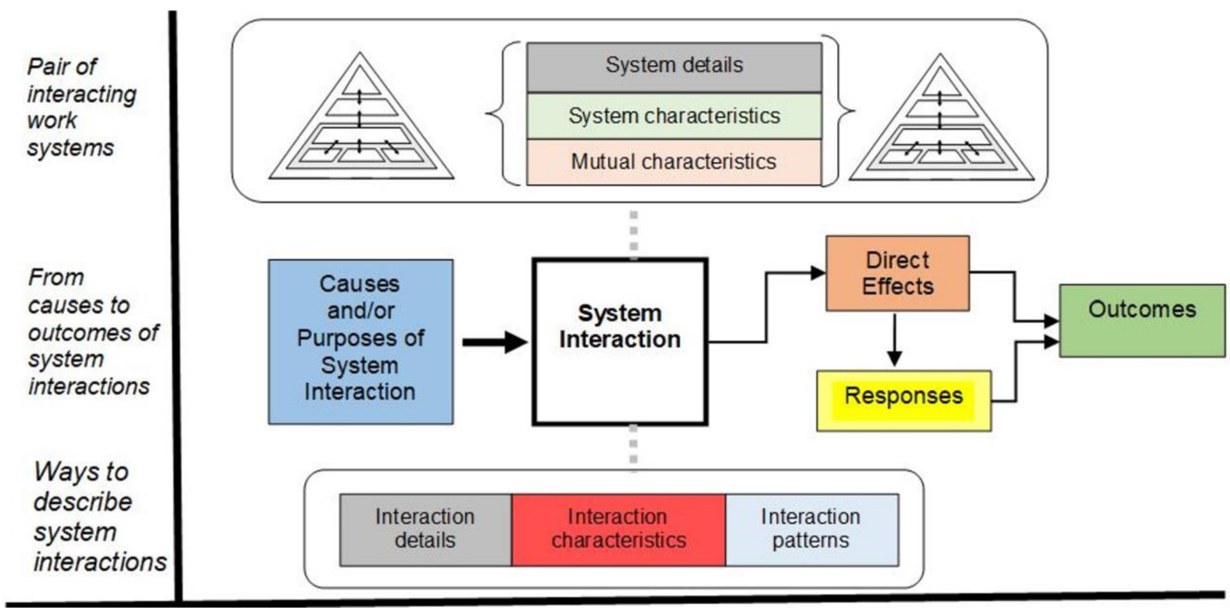


Figure 22. Work system interactions, as described by system interaction theory

TFIS 6: Generalizations

Identifying Axioms that Apply to All Work Systems [21]

- WS axioms are assumed to be true for all work systems.
- WS axioms can be challenged by identifying WS or IS examples that do not conform.
- Each axiom leads directly to questions that are useful for visualizing and understanding a WS.
- These axioms are abbreviated to a single line but have been stated and explained fully elsewhere.

--- Work Systems in Context ---
A1: A WS is an **open system** that receives inputs and generates outputs.
A2: A WS brings espoused intentions of beneficial outcomes for one or more **beneficiaries**.
A3: **Stakeholders** of a WS include its beneficiaries and others who care about its operation and outputs.
A4. Direct and/or indirect **interactions with the environment** matter for every WS.
--- Work Systems in Operation ---
A5: A WS performs **activities** or action.
A6: A WS requires organizational, technical, informational or societal **resources.**
A7: Implicit or explicit **regulation** guides or controls activities in a WS
A8. A WS operates through direct and indirect **internal interactions** between its components.
A9: A WS performs **external interactions** to produce or transfer benefits to beneficiaries.
A10: **Management and maintenance** of a WS uses and/or consumes resources.
A11: A nontrivial WS is a **system of systems** that individually conform to the other axioms.
--- Work System Goals and Goal Attainment ---
A12: Attainment of **multiple goals** of a WS is affected by its form, characteristics, and operation.
A13. Implicit or explicit **trade-offs** result from conflicts between internal and external goals.
A14: **Internal alignment** of WS goals with WS components and interactions affects goal attainment.
A15: **External alignment** with value-creating activities of beneficiaries affects goal attainment.
A16: **Congruence** (similarity of form, logic, and details) within a WS facilitates WS operation.
A17: **Operational fit** between WS form, logic, and complementary resources affects goal attainment.
A18: **Requisite variety** of a WS requires recognizing and responding to situations it will encounter.
--- Work System Uncertainties ---
A19: **Agency** of human and automated actors implies that a WS may or may not pursue stated goals.
A20: Both **compliance and noncompliance** to WS specifications may be beneficial or harmful.
A 21: **Uncertainty** of outcomes stems from inability to predict WS operation and outputs exactly.
--- Work System Change ---
A22. **Design incompletion** results from ongoing changes in the organization and the environment.
A23. A WS evolves over time through a combination of **planned and unplanned change**.
A24. Due to **path dependence**, the feasibility of future changes depends on the path of past changes.
A25: The **absorptive capacity** of a WS is related to its structure, available resources, history, and other factors.

Figure 23. Work system axioms

TFIS 6: Generalizations

Identifying Design Principles that Apply to Most Work Systems [22]

- Work system design principles provide broadly relevant guidance, but are mutually inconsistent in some situations (e.g., please the customers vs. do the work efficiently).
- The design principles below are abbreviated versions of statements in the form "Do X to obtain result Y under circumstance Z." X may be vague, and Y and Z may or may not be stated explicitly in many purported design principles, design theories, rules of thumb, and other forms of general guidance.
- The following design principles apply to sociotechnical work systems. They were developed iteratively, incorporate versions of Cherns' sociotechnical principles, and were sanity-checked based on responses of EMBA students. Researchers and practitioners have proposed many other sets of design principles.

<table>
<tr><th colspan="2">Customers</th><th colspan="2">Product/Services</th></tr>
<tr><td colspan="4">• #1: Please the customers.
• #2: Balance priorities of different customers.</td></tr>
<tr><th colspan="4">Processes and Activities</th></tr>
<tr><td colspan="4">• #3: Match process flexibility with product variability
• #4: Perform the work efficiently.
• #5: Encourage appropriate use of judgment.
• #6: Control problems at their source.
• #7: Monitor the quality and timing of both inputs and outputs.
• #8: Boundaries between steps should facilitate control.
• #9: Match the work practices with the participants.</td></tr>
<tr><th colspan="2">Participants</th><th>Information</th><th>Technologies</th></tr>
<tr><td colspan="2">• #10: Serve the participants.
• #11: Align participant incentives with system goals.
• #12: Operate with clear roles and responsibilities.</td><td>• #13: Provide information where it will affect action.
• #14: Protect information from inappropriate use.</td><td>• #15. Use cost/effective technology.
• #16: Minimize effort consumed by technology.</td></tr>
<tr><th>Infrastructure</th><td colspan="3">• #17: Take full advantage of infrastructure.</td></tr>
<tr><th>Environment</th><td colspan="3">• #18: Minimize unnecessary conflict with the external environment</td></tr>
<tr><th>Strategies</th><td colspan="3">• #19: Support the firm's strategy</td></tr>
<tr><th>Work System as a Whole</th><td colspan="3">• #20: Maintain compatibility and coordination with other work systems.
• #21: Incorporate goals, measurement, evaluation, and feedback.
• #22: Minimize unnecessary risks.
• #23: Maintain balance between work system elements.
• #24: Maintain the ability to adapt, change, and grow.</td></tr>
</table>

Figure 24. Design principles for sociotechnical work systems

TFIS 6:
Generalizations

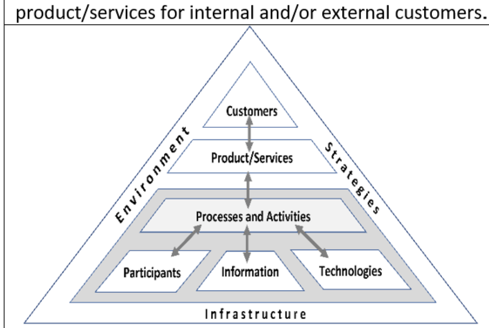
Identifying Theories Related to Work Systems [23,24]

- The on-going debate in academia about the nature of proper theories leads to questioning whether many generalizations that are relevant to IS should be called theories, frameworks, models, or something else. The TFIS assumes that a theory is a justified statement or argument about how to understand, explain, or design an entity or phenomenon.

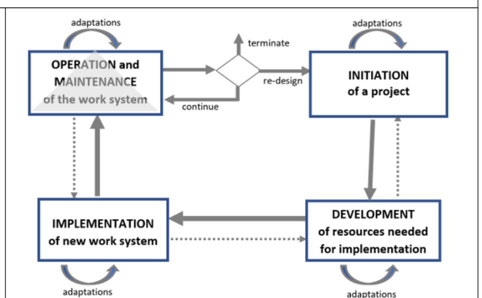
- The TFIS views theory as a type of generalization that is not inherently superior to other types of generalizations.

Work system theory is the core of the work system perspective. [1,2,3]

Definition of work system. WST defines work system as a system in which human participants *and/or* machines perform work (processes and activities) using information, technology, and other resources to produce specific product/services for internal and/or external customers.



Work System Framework



Work System Life Cycle Model (WSLC)

The theory of workarounds is one of several theories that are extensions of work system theory. [16]

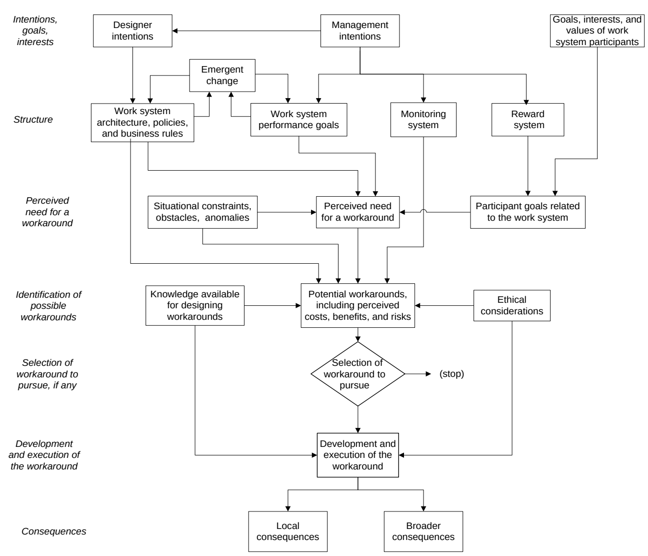


Figure 25. Examples of theories related to work systems

TFIS 6: Generalizations

Describing Services using a Framework that Extends WST [25]

- Figure 26, the service value chain framework, was designed to bring an explicit focus on service to discussions of WSs and ISs.

- This framework applies to sociotechnical and automated WSs and ISs. It can be used in conjunction with the work system framework or independently. It emphasizes:

  — Responsibilities of providers and customers
  — Provider-customer interactions
  — Common activities in service provision (set-up, service request, fulfillment, follow-up)
  — Extent of mutual visibility by providers and customers

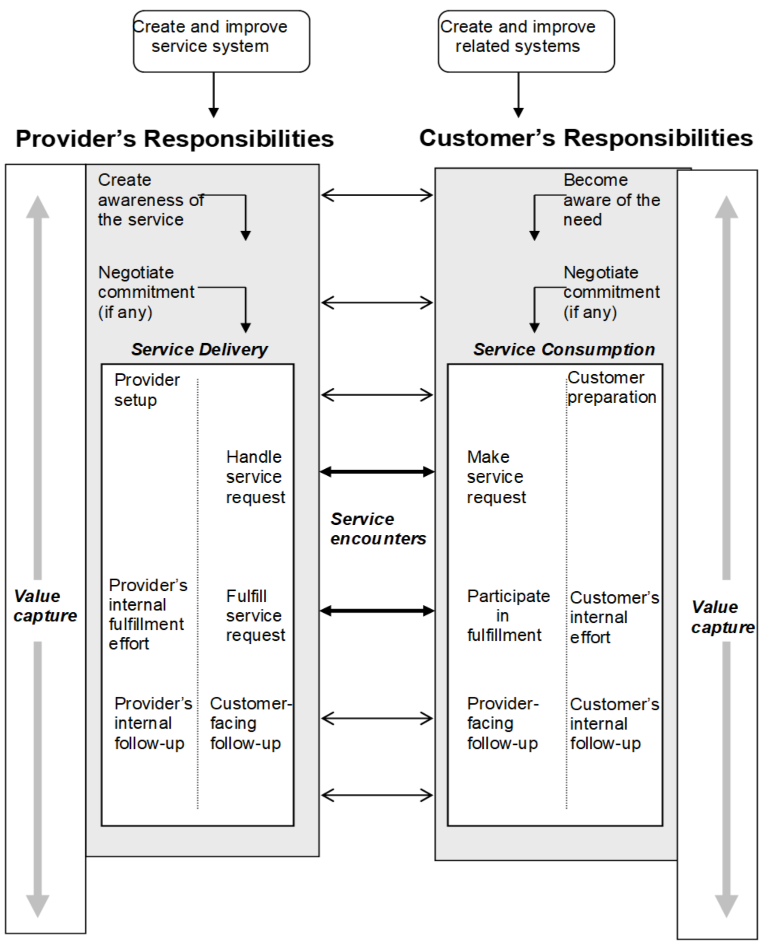


Figure 26. Service value chain framework

TFIS 6: Generalizations

Restating the Work System Framework : a Complex Work System Metamodel [26,27]

- Figure 27 restates every element of the work system framework in a more detailed form that shows relationships through which work systems operate and serve their customers.
- This metamodel expresses relationships and identifies types of resources that are only implied in the work system framework, which was designed for ease of explanation and use in discussions.
- Figure 27 is the sixth of a series of metamodels that tried to address limitations of the work system framework. Its complicated appearance makes it difficult to explain to most business professionals. Its main direct use is in clarifying ideas and as a source of analysis, design, and evaluation tools for SA&D.

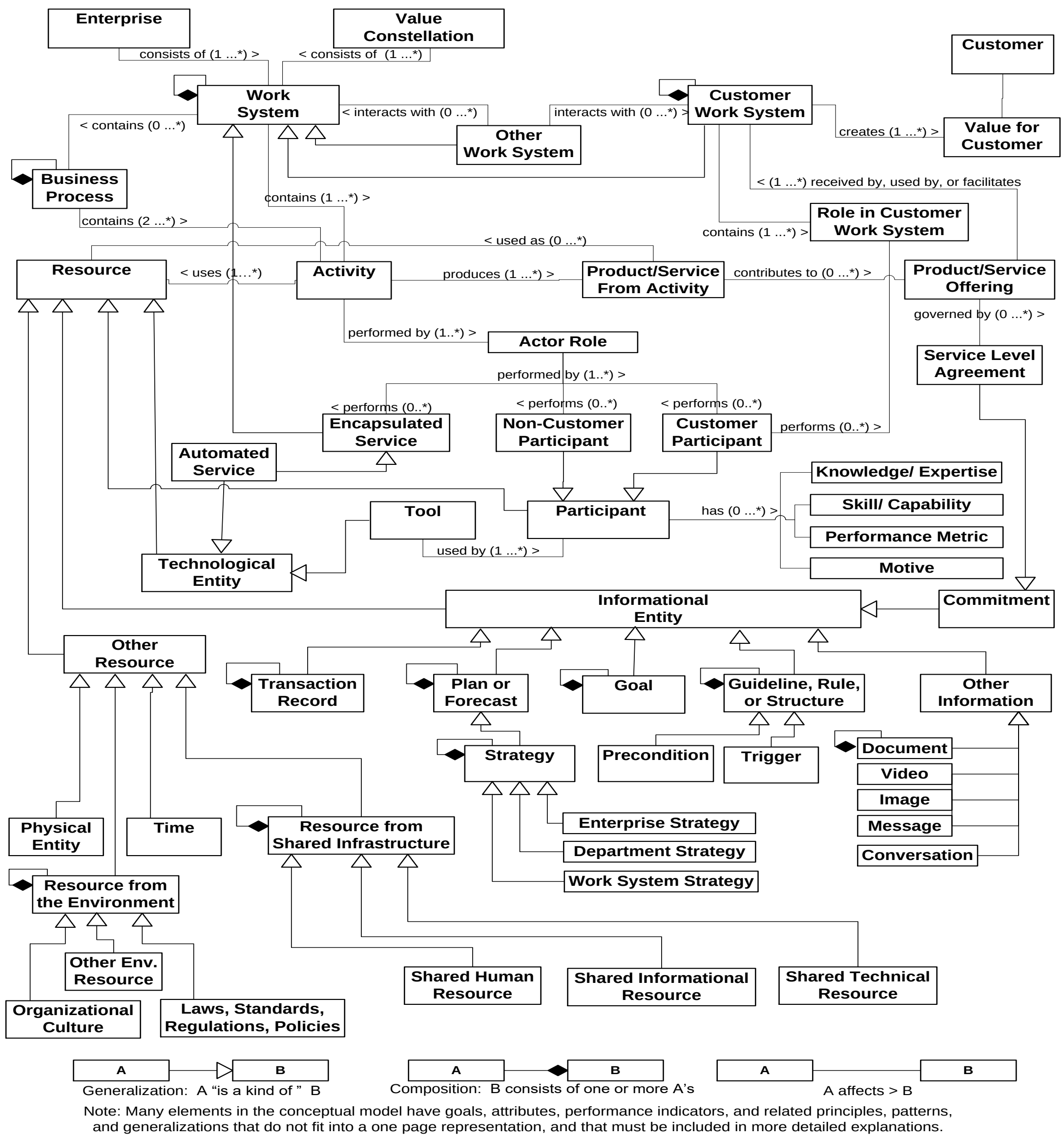


Figure 27. A complex work system metamodel

TFIS 6:
Generalizations

TailoringAlternative WS Metamodels for Different Stakeholder Purposes [28]

- Making enterprise and process modeling more accessible to different groups of stakeholders who need to collaborate requires relaxing the assumption that a single WS/IS metamodel should serve the needs and purposes of all stakeholders. Instead, a design space for modeling methods could imply different metamodels for different purposes (e.g., P1 through P6 in Figure 28).

- The general approach is to use alterative metamodels based on the same "modeling metaphor." The linked metamodels below treat "work system" as a common modeling metaphor and model work systems in different ways that are suited to different stakeholder purposes. The P3 metamodel is most closely attuned to the work system framework. The P5 metamodel accommodates modeling along the lines of typical process modeling.

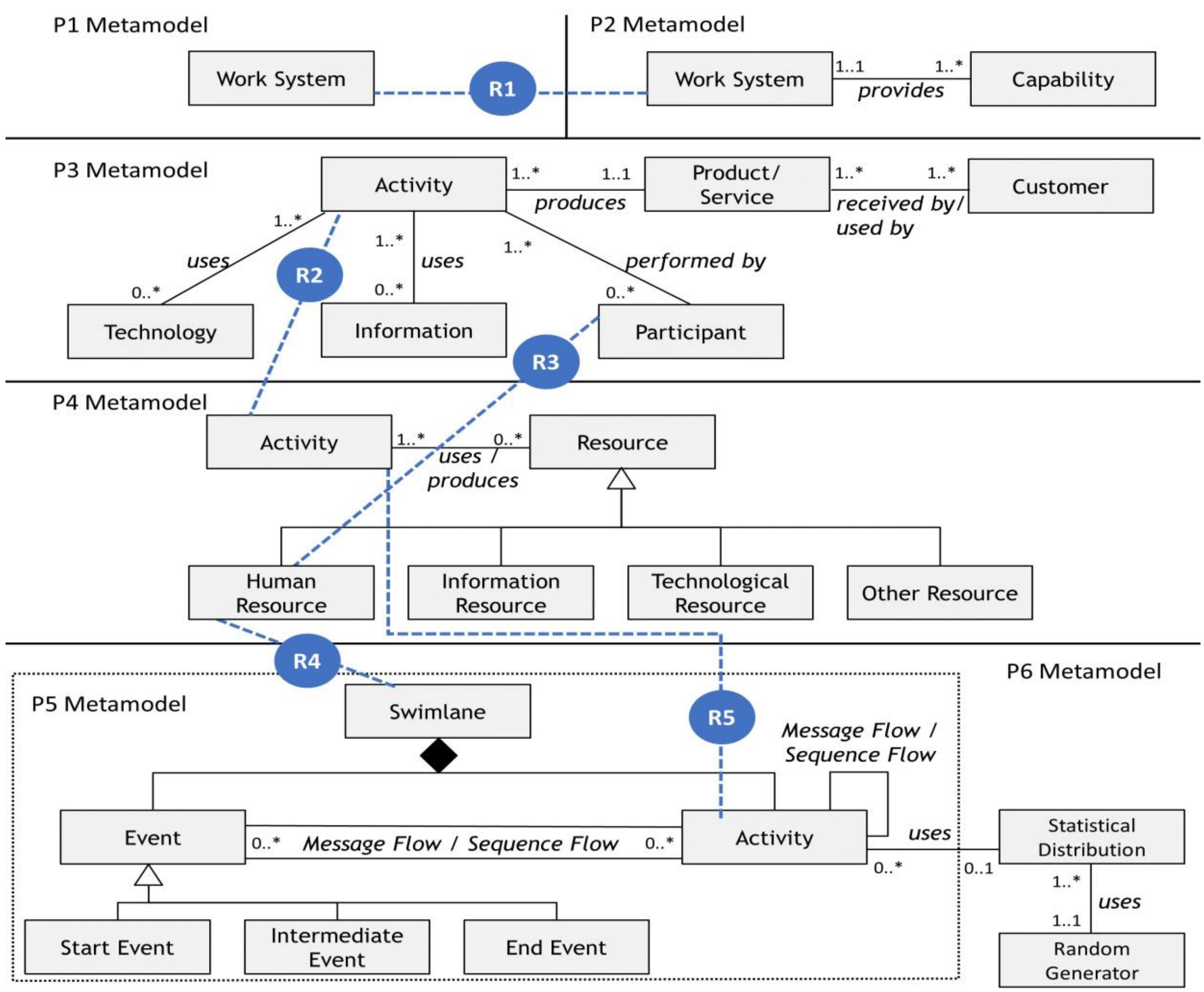


Figure 28. Alternative work system metamodels for different stakeholder purposes

Generalization and a Use Case

Applying Work System Theory: The Work System Method [1,2]

- The work system method (WSM) is a semi-formal SA&D approach designed to help business professionals visualize WSs in their own organizations and collaborate more effectively with IS/IT professionals. During 2003-2017, individual students or teams of students (mostly employed MBA and Executive MBA) used various versions of WSM to produce over 700 management briefings recommending improvements of problematic IT-enabled WSs, mostly in their own firms.

- The WSM is relevant to ISs because IS is a special case of WS and because many ISs exist to support other WSs. In both instances, WSM provides an organized approach for describing and evaluating a situation.

- While details differ, every version of WSM is organized as follows:

1) Identify the smallest WS that has the problem or opportunity that launched the analysis and summarize performance gaps, major strengths and vulnerabilities, key incidents, and so on.

2) Summarize the “as-is” WS using a WS snapshot, a stylized one-page summary.

3) Evaluate the WS’s operation using measures of performance, key incidents, social relations, and other factors.

4) Drill down further as necessary.

5) Propose changes that are summarized by using a WS snapshot of a proposed “to be” WS that should perform better.

6) Describe likely performance improvements and explain why related change project is justified.

Use Case

Summarizing a WS or IS Using a a Central Tool from WSM [29,30]

- Figure 29 illustrates the form and content of a work system snapshot, which is a central tool in WSM. The table represents a hypothetical work system snapshot that was designed to discuss possible AI applications in hiring. MBA and EMBA students find this type of model relatively easy to produce and use for delineating the scope of a sociotechnical WS or IS. They typically start by identifying participants and activities in the WS and then identify product/services and customers. That approach helps them realize that the WS or IS is the headline, not the technology.

- This relatively lightweight type of model maintains a degree of rigor by requiring that participants perform at least one activity, that informational entities must be created or used in at least one activity, that product/services for customers result directly from one or more activities, and so on.

<table>
<tr><th colspan="2">Customers</th><th colspan="2">Product/services</th></tr>
<tr><td colspan="2">• Applicants
• Hiring manager
• Larger organization
• HR manager (who will use the applications to analyze the nature of applicants)</td><td colspan="2">• Applications (which may be used for subsequent analysis)
• Job offers
• Rejection letters
• Hiring of the applicant</td></tr>
<tr><th colspan="4">Major activities and processes</th></tr>
<tr><td colspan="2">• AlgoComm publicizes the position.
• Applicants submit resumes to AlgoComm.
• AlgoRank selects shortlisted applicants and sends the list to the hiring manager.
• Hiring manager decides who to interview.
• AlgoComm sets up interviews.</td><td colspan="2">• Interviewers perform interviews and provide comments about applicants.
• AlgoRank evaluates candidates.
• Hiring manager makes hiring decision.
• AlgoComm notifies applicants.
• Applicant accepts or rejects job offer.</td></tr>
<tr><th>Participants</th><th colspan="2">Information</th><th>Technology</th></tr>
<tr><td>• Hiring manager
• Applicants
• Other employees who perform interviews</td><td>• Job requisition
• Job description
• Advertisements
• Job applications
• Cover letters
• Applicant resumes</td><td>• Applicant short list
• Information and impressions from the interviews
• Job offers
• Rejection letters</td><td>• AlgoComm
• AlgoRank
• Office software
• Internet</td></tr>
</table>

Figure 29. Example illustrating a work system snapshot

Use Case

Proposing a Toolkit for Modeling, Analyzing, and Designing Work Systems [31,32]

- The many ideas in the TFIS form the basis for a proposed toolkit that business and IT professionals can use to understand and collaborate around IS-related business situations. The toolkit would contain the work system snapshot (Figure 29) and other easily understood modules for modeling, analysis, and design.
- Figure 30 identifies representative modeling, analysis, and design modules and provides excerpts from longer examples that illustrate lightweight tools directly related to the TFIS.
- The entire approach assumes that any appropriate tools for expert analysts such as BPMN will be used where needed even though they are not integral parts of the TFIS.

Modeling modules	Analysis modules	Design modules
• Identification • Capabilities • Operation and scope of the WS • Value capture • Responsibilities • Visibility • Activity/resource dependencies • System interactions • Diagrammatic specifications	• Problems and opportunities • Performance gaps • Strengths and weaknesses • Exceptions • Workarounds or noncompliance • Key incidents • Risks • Issues for elements of the work system framework	• Proposed changes in the work system • Rationale for proposed changes • Likely improvements in work system performance

Provider responsibility	Activity (from the work system snapshot)	Customer Responsibility
Request for new hire only if that fits within an relevant budget.	Submit request for new hire.	
Conform with corporate standards in specifying job parameters.	Define job parameters.	
Publicize in places that are likely to be visible to appropriate candidates.	Publicize the position.	
Provide a convenient way for applicants to submit resumes.	Submit resumes.	Submit honest, well-constructed resume

Facet	Opportunities, problems, and issues
Making decisions	Past hiring decisions often were not well considered. Too many engineers left the company before they add a lot of value.
Communi-cating	Communication with interviewers was often ineffective. In some cases the manager seemed unwilling to engage seriously about interviewer criticisms of candidates.
Processing information	Compilation of interview feedback often seems slow and ineffective.

Work system principle	*Fit*	*Comment*
#1: Please the customers.	3	No one really satisfied
#2: Balance priorities of different customers.	3	Manager versus applicants
#3: Match process flexibility with product variability.	2	Flexible enough
#4: Perform the work efficiently.	3	Too much wasted time

Element	Workarounds that have occurred in the hiring system
Work system as a whole	Some hiring occurs completely outside of the hiring system. In those instances, data is entered into the system mainly after the hiring occurs.
Customers	Some important hires occurred when applicants went directly to employees that they knew instead of starting their applications through the HR portal.
Product/services	In conflict with a privacy pledge for applicants, the HR department previously combined information from resumes with ostensibly private information from other sources.

Figure 30. Examples illustrating representative modules from the proposed toolkit

Use Case

Understanding IS User Satisfaction [33]

- Figure 31 uses shading to indicate the relative prominence of specific elements of the WS framework in positive and negative comments about IS user satisfaction in 111 recorded interviews from 5 cases studies by Laumer and Associates that were commissioned by IT managers to help them address IS user satisfaction issues.
- The diagram for each of the five cases highlights the presence of issues that were reported by users and stakeholders but that would be missed by TAM, UTAUT, IS success model, and task/technology fit, all of which focus on only several work system elements.
- The analysis supports the intuitively plausible assumption that IS user satisfaction may be affected by every part of the WS that is supported by the IS. The conclusion is a new theory of IS user satisfaction that does not rely on commonly cited models such as TAM and UTAUT and can be tested further in future research: …… "The primary driver of user satisfaction for an IS that supports a WS is the degree to which the IS contributes to an individual user's efficiency in executing responsibilities within the WS and effectiveness in serving the WS's customers."

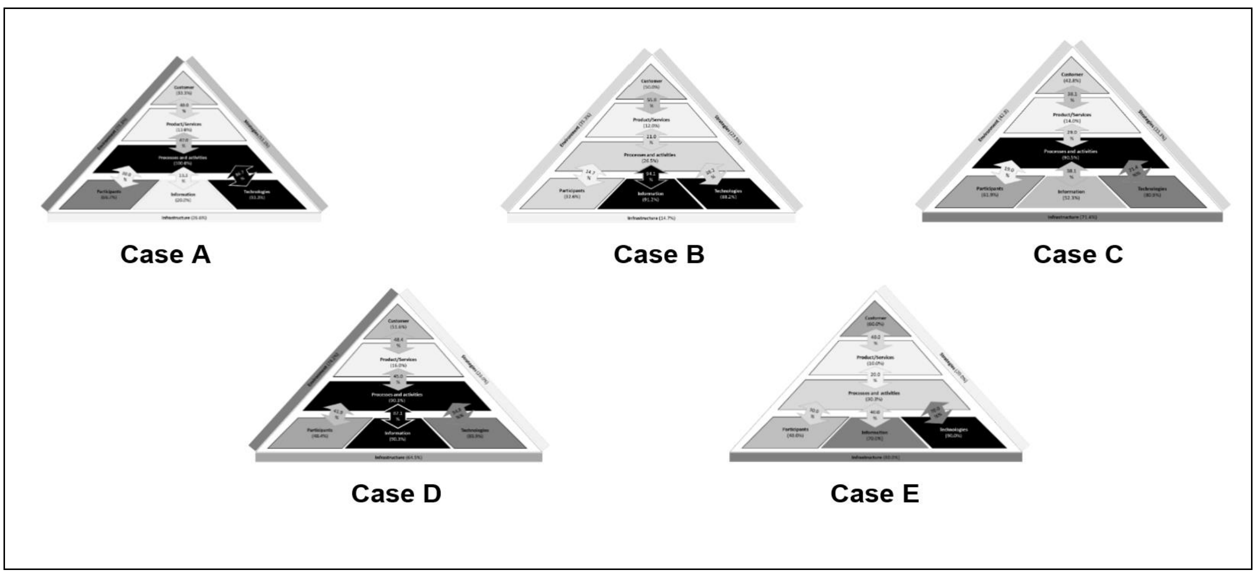


Figure 31. Relative prominence of different parts of the work system framework in comments about IS user satisfaction in 111 recorded interviews from 5 case studies

Use Case

Describing, Analyzing, or Evaluating Aspects of IS Security [34]

- IS security practices need to address internal and external sources of security threats that may be intentional or accidental and may result from malfeasance or simple neglect.
- The TFIS brings at least six lenses for visualizing threats and implementing responses.

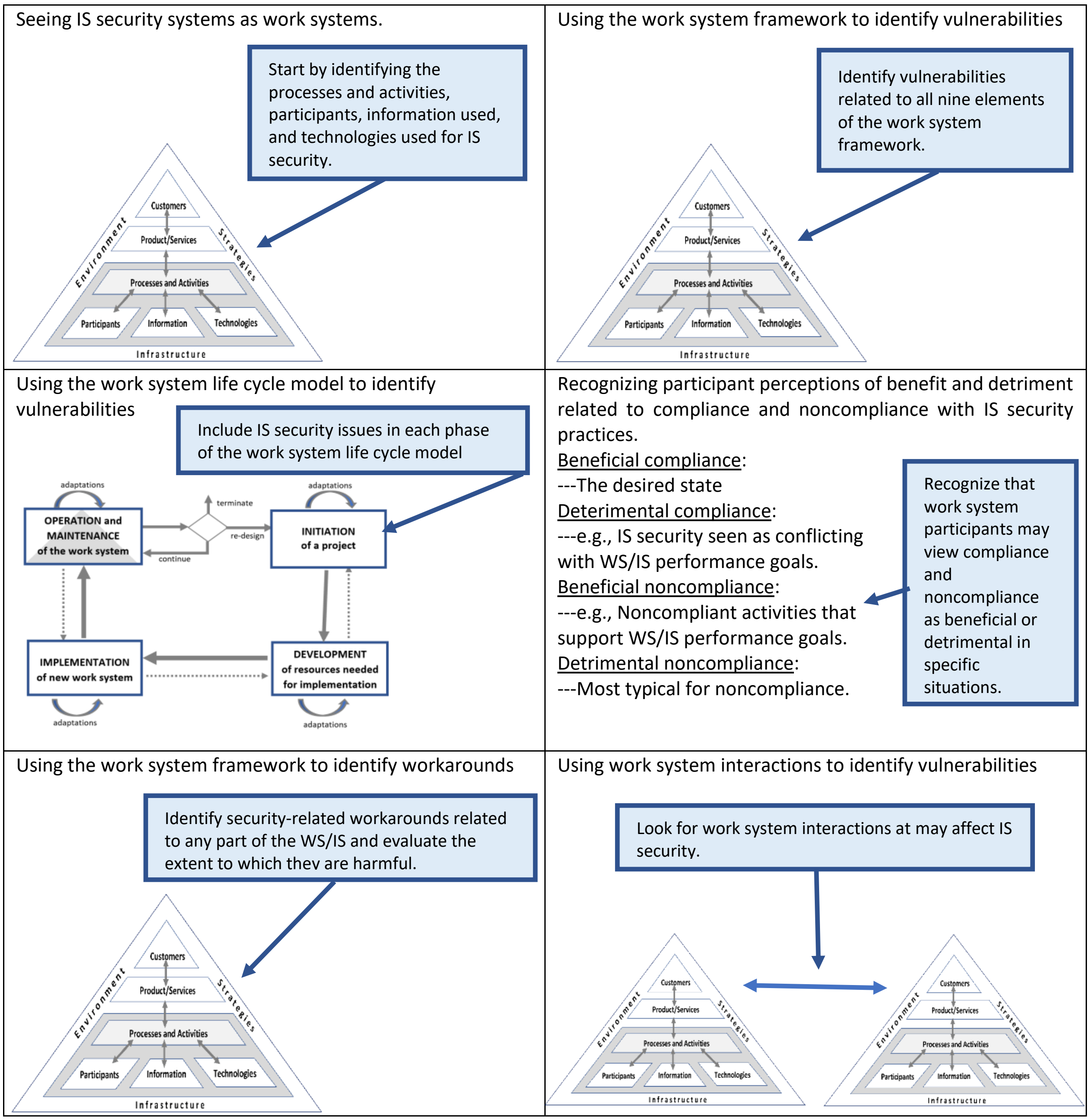


Figure 32. Six lenses for describing, analyzing, or evaluating aspects of IS security

Use Case

Understanding Artificial Intelligence in a Usage Context [35]

- Instead of trying to generalize about AI potential, AI risks, AI ethics, etc., think of AI-based tools as algorithms that are used in specific WSs.
- Issues concerning AI potential, AI risks, and AI ethics for a specific AI-supported WSs stem from how successive versions of the AI-supported WS are imagined, developed, implemented, and operated and maintained as the WS evolves over time. Figure 33 emphasizes issues related to the AI algorithm.

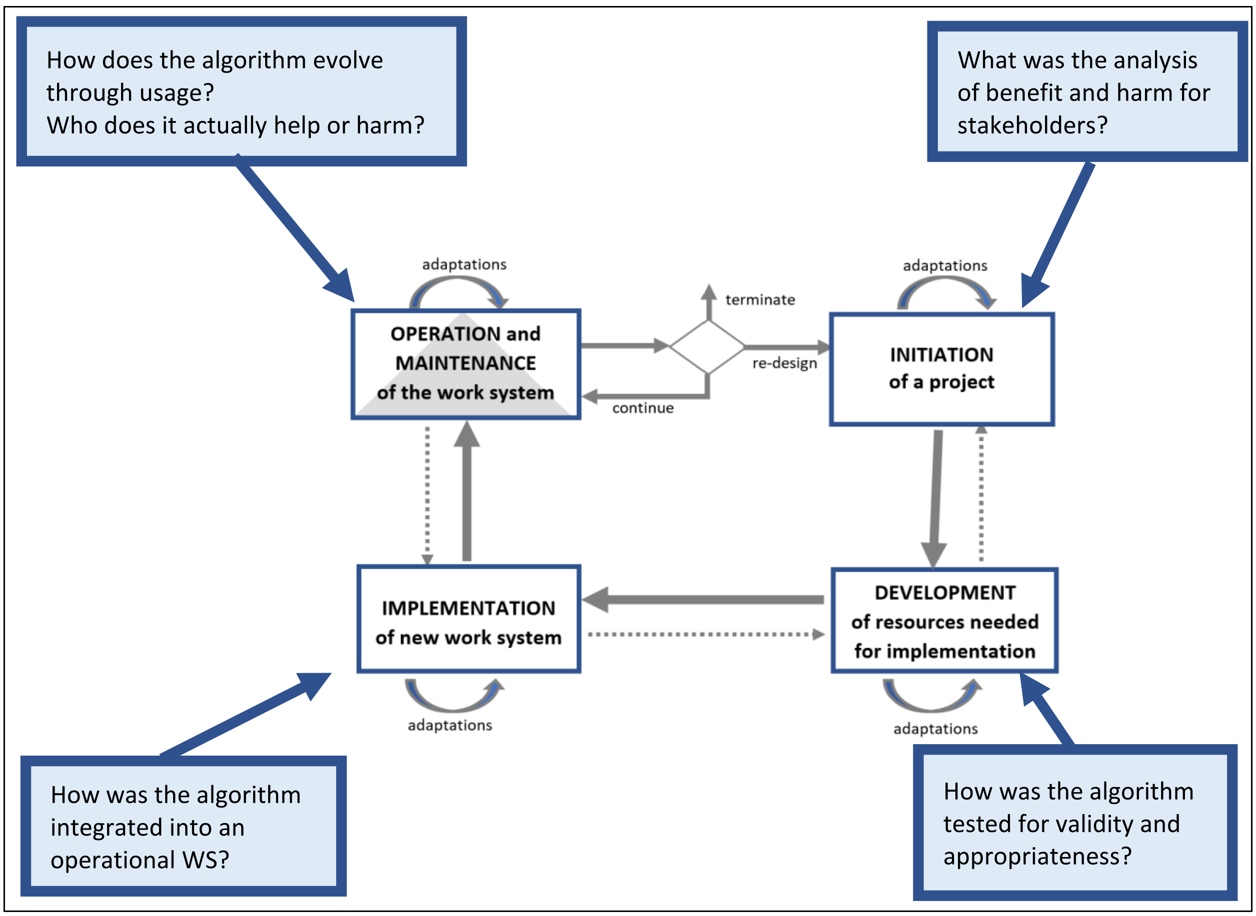


Figure 33. Understanding artificial intelligence in a usage context

Use Case

Visualizing the Smartness in Nominally "Smart" Systems and Devices [36]

- In topics related to IS, the term smart has been associated with anything from artificial intelligence to smart cities, smart cars, smart clothes, smart dust, smart databases, smart locks, smart manufacturing, smart whiteboards, smartphones, smart contracts, smart bombs, etc.
- Using dimensions of smartness could help in describing smart devices and systems as a way to make sense of what might be meant when people talk about nominally "smart" systems and devices.
- Figure 34 divides many dimensions of smartness among four broad categories.
- The bottom of Figure 34 notes that each dimension starts with "not smart at all" along that dimension and shows steps toward greater smartness. Those progressions show that most nominally smart things are not so smart after all.

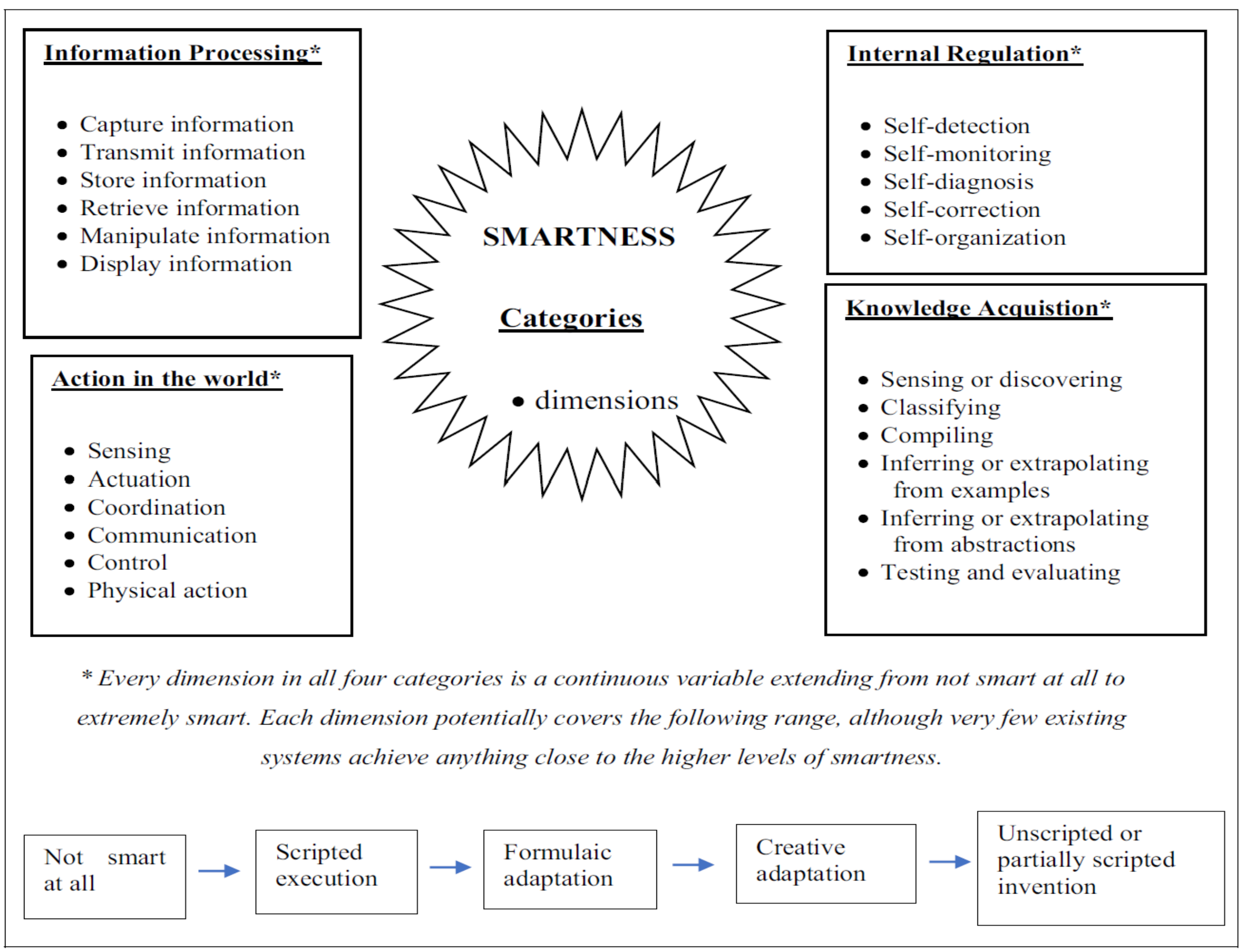
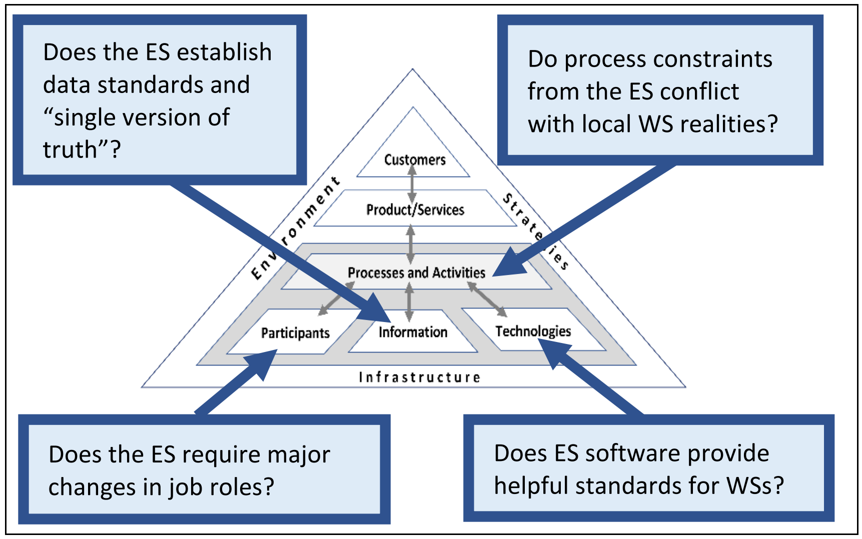


Figure 34. Visualizing the smartness in nominally "smart" systems and devices

Use Case

Understanding Enterprise Systems in a Usage Context

- ESs can be viewed as infrastructure shared by multiple WSs



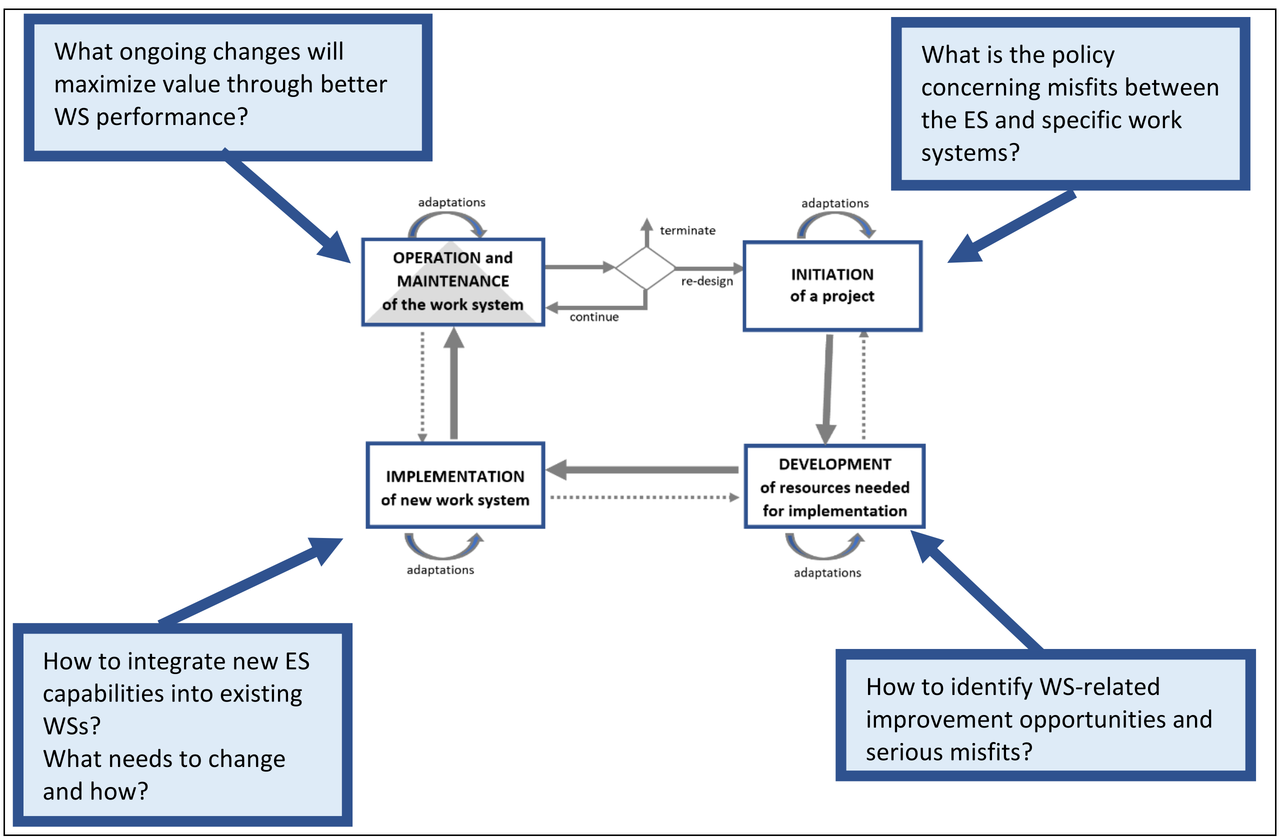
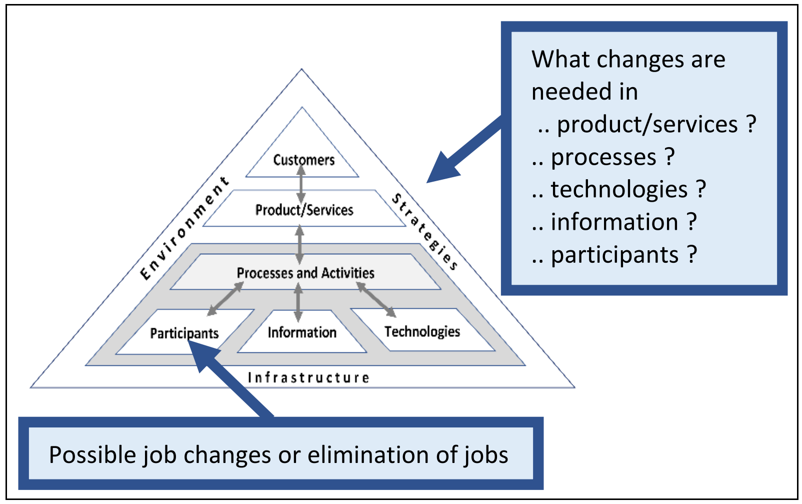


Figure 35. Understanding enterprise systems in a usage context

Use Case

Understanding Outsourcing and Platforms in a Usage Context (including IaaS, SaaS, PaaS)

- Outsourcing can involve any element of a WS (e.g., contractors as participants, information that might be purchased, technology that might move to the cloud, etc.)
- Use of commercial platforms can be viewed as a type of outsourcing.



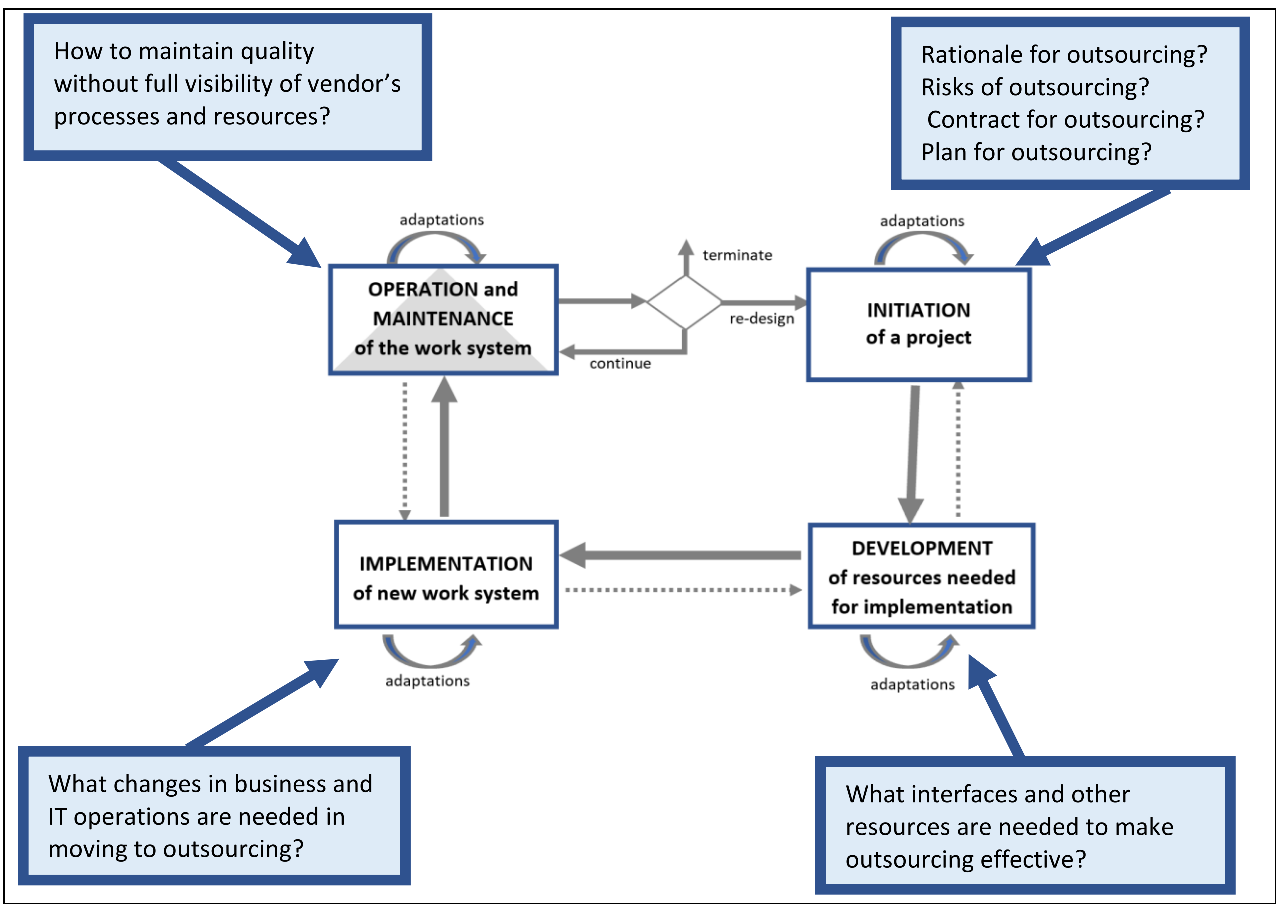


Figure 36. Understanding outsourcing and platforms in a usage context

Use Case

Visualizing Causes of Success or Problems in IS Case Studies

- Using a work system perspective to visualize both the IS and the WS that it supports can help in understanding causes of successes and problems plus reasons why value is or is not achieved.

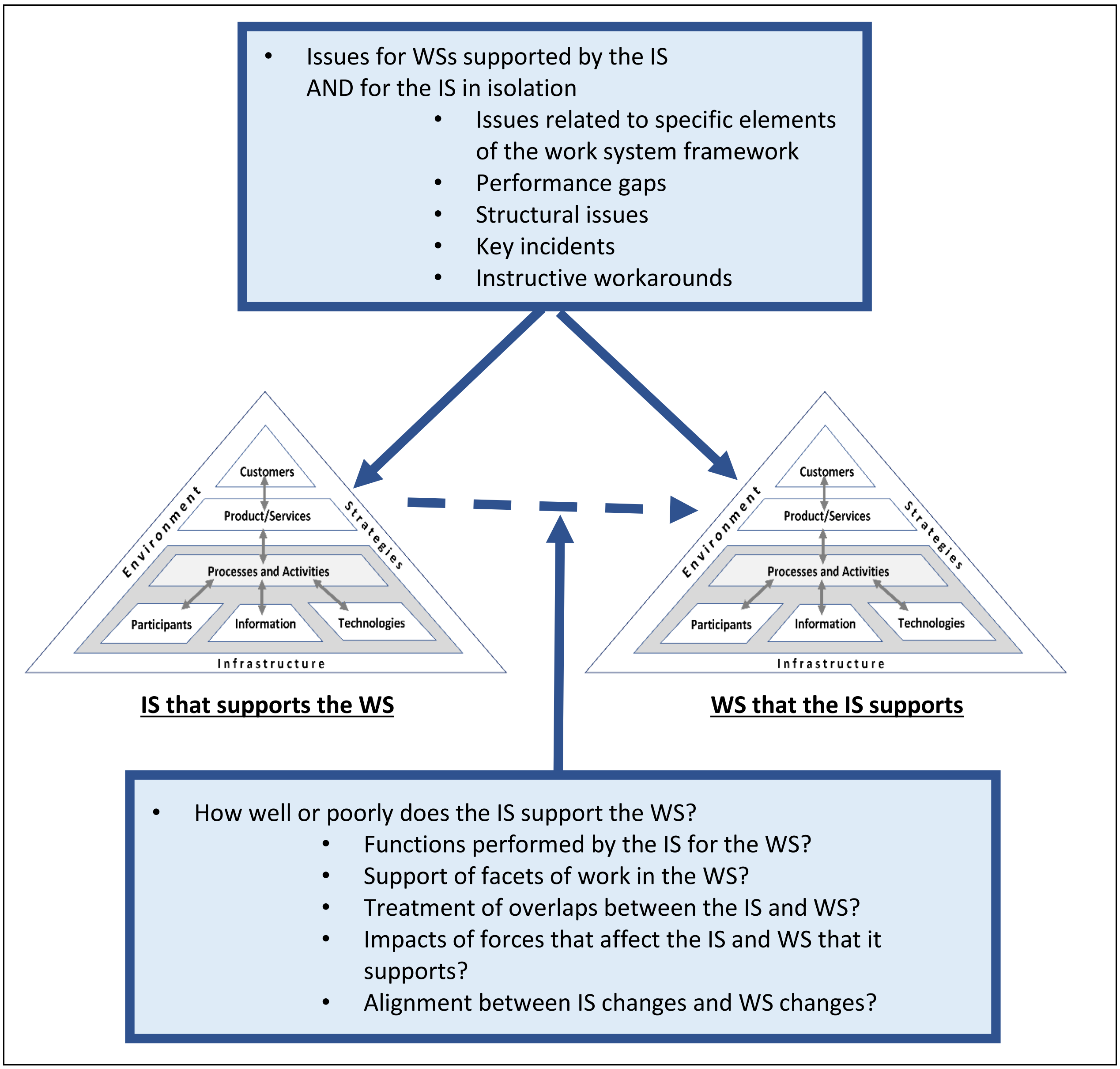


Figure 37. Visualizing situations in IS case studies related to systems

Potential Use Case

Compiling a First Cut at the System-Related Part of an IS Body of Knowledge [37]

- Use a taxonomy of knowledge objects (KOs) to identify knowledge.

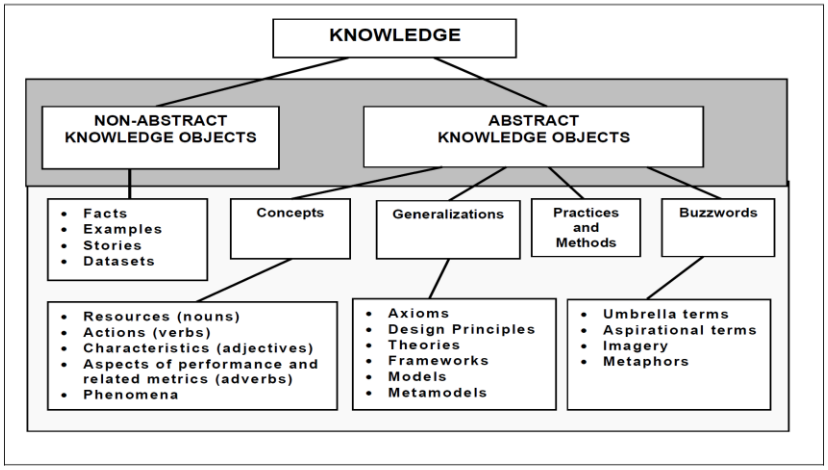


Figure 38. A taxonomy of knowledge objects

- The taxonomy assumes that science is the creation, evaluation, accumulation, dissemination, synthesis, and prioritization of KOs, including the reevaluation, improvement, or replacement of existing KOs by other KOs that are more effective for understanding the relevant domain.
- Existing knowledge about important types of WSs, ISs, and projects includes most of the taxonomy's KO types. Importantly, this is much more than just theories.

- Use a spreadsheet to compile a first cut of relevant KOs. The following example illustrates a possible format of the spreadsheet.

Knowledge Object	**Type of KO**	**Most general WS type**	**Applies to**
Scalability	Characteristic	WS in general	WS as a whole
Precision	Characteristic	WS in general	Information
Accuracy	Performance variable	WS in general	Information
Error rate	Performance variable	WS in general	Processes and activities
Techno-stress	Phenomenon	Sociotechnical WS	Participants
Start date	Characteristic	Project	Processes and activities
Escalation of commitment	Phenomenon	Project	Project as a whole
"Do the work efficiently"	Design principle	WS in general	Processes and activities
TAM	Theory	WS in general	Technology
Cognitive load theory	Theory	Sociotechnical WS	Participants
Absorptive capacity	Phenomenon	WS in general	WS as a whole
Agile manifesto	Design principle(s)	Software project	Software project
Understandability	Performance variable	WS in general	Communicating (a facet)
Coordination theory	Theory	WS in general	Coordinating (a facet)
Responsiveness	Performance variable	WS in general	Providing service (a facet)
Capturing information	Action	WS in general	Processing information (a facet)

Figure 39. Illustration of a spreadsheet format for compiling KOs for an IS body of knowledge

Potential Use Case

Establishing Stronger Conceptual Links with the Content of Other Disciplines [38,39]

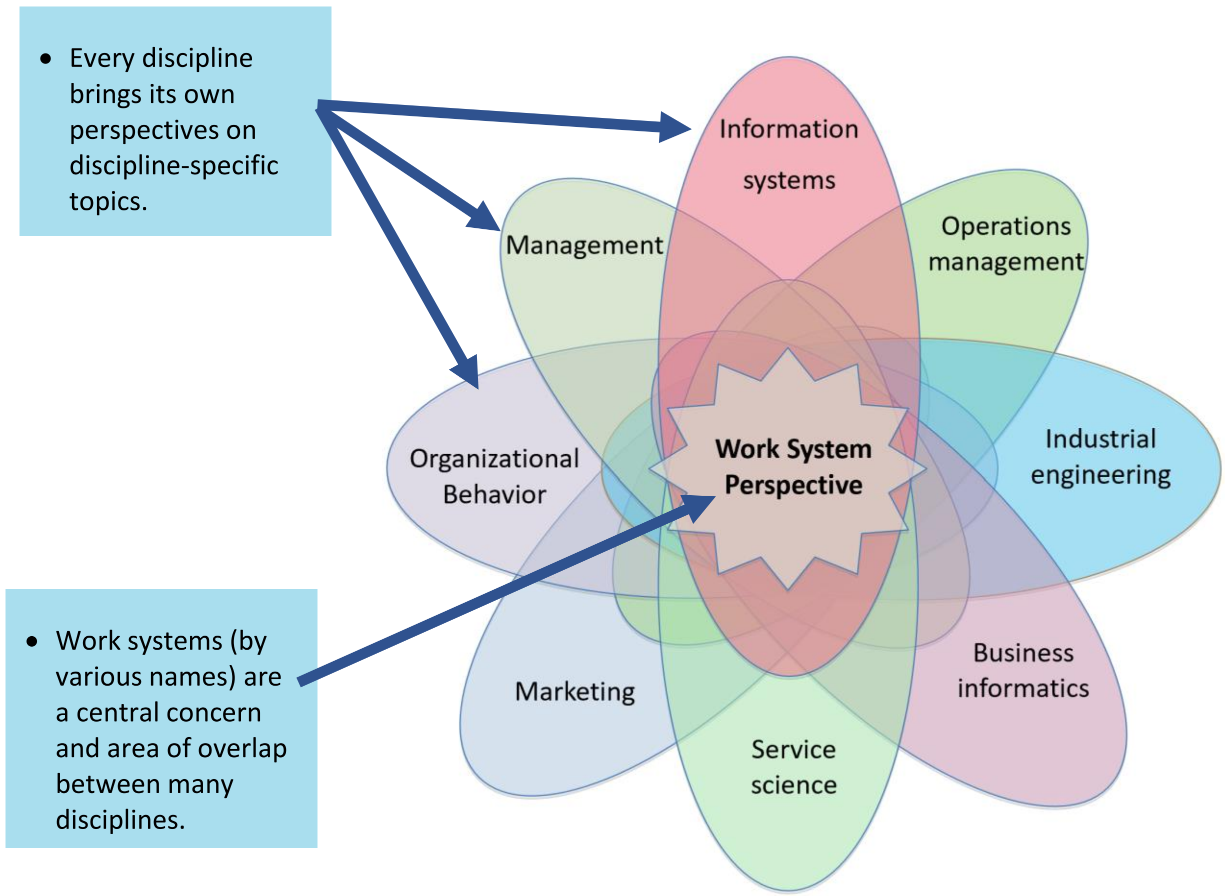


Figure 40. Potential for the using the work system perspective to establish stronger conceptual links with the content of other disciplines

- The work system perspective could provide linkage between disciplines that are serious about systems.
- This could be a path toward greater cooperation across academic silos.

Evaluation

A Step in a Positive Direction?

- <u>Face validity</u>
  - A well-established systems approach to understanding systems in organizations
  - Understandable enough to be used in teaching and research
- <u>Coherence</u>
  - Based on a well-articulated core (work system theory)
- <u>Completeness</u>
  - In relation to IS content, more complete than most frameworks, 2X2s, theories, and philosophical inquiries that focus on system-related content. Broader than tool-oriented approaches such as BPMN, UML, ArchiMate, etc.
  - Explicitly omits many important topics related to operation of IT groups, overall business strategy, digital divide, impacts on society, use of apps for personal amusement, etc.
- <u>Parsimony</u>
  - Treats parsimony as a much lower priority than coherence, completeness, and usefulness
- <u>Usefulness</u>
  - Main ideas have been used in teaching and research
  - Many valuable use cases
- <u>Generativity</u>
  - A unified approach to information systems and other special cases of work system that may be totally social, partly automated, or totally automated.
  - Shared core for many disciplines leading to possible integration across academic silos.
  - A point of comparison for TFIS approaches based on other possible starting points including general systems theory, sociotechnical systems theory, the Bunge-Weber-Wand (BWW) ontology, soft system methodology, activity theory, the viable system model, and so on.
  - A point of comparison for examining past and current use of concepts such as system, information system, usage, IT artifact, digitalization, artificial intelligence and so on.

Summary of the Proposed Theoretical Foundation for the IS Discipline

Justification	*Rationale*

Rationale. The work system perspective forms a plausible basis of a TFIS because it provides a comprehensive, organized, and flexible way to identify the core subject matter of the IS field and discuss that subject matter in depth. That subject matter involves IT-enabled work systems in organizations. ISs, IS-related projects, and other relevant special cases can be viewed as WSs and therefore inherit many of the concepts and generalizations in the work system perspective.

Coverage	*Domain, Omissions*

Domain: The proposed TFIS covers sociotechnical and automated WSs and ISs of all types and sizes in organizational settings (in contrast with totally personal IS/IT applications and other topics that are not specifically about systems in organizations). Seeing the domain as including both sociotechnical and automated WSs and ISs is important for covering hybrid and automated ISs that are created in initiatives related to digitalization, artificial intelligence, robotic process automation, and related trends. The proposed TFIS has highest acuity and efficacy when focused on the operation and/or development of ISs and IT-enabled WSs of the types that most business professionals encounter in their everyday work. It is less useful for understanding personal systems, network infrastructures, business/IT alignment, and other topics that are less directly related to the operation and evolution of systems in organizations.

Omissions: The proposed TFIS emphasizes the operation and evolution of ISs and related groups of IS but treats many important IS-related topics as secondary or only indirectly related to the TFIS. Examples of topics outside the main emphasis of the TFIS include IS/IT organizations, IS/IT careers, the aggregate business value of IT, impacts of IT on society in general, uses of IT for individual amusement, organizational culture, ethics, the nature of competition, and personal motivational topics covered by physiology, psychology, and marketing. The TFIS does not include explicit coverage of BPMN, UML, ERD, and other tools and methods that IT professionals use for producing rigorous specifications of activities, information, and software and hardware technologies.

Focal Points	*Primary Entity Types, Special cases, Facets, Portrayals, Functions, Overlaps*

Primary entity types. The primary entity types are ISs (a special case of WS) and the nine elements of the work system framework, which outline a basic understanding of a IS's form, function, and environment during a period when it is stable enough to retain its identity even though incremental changes may occur, such as minor personnel substitutions or technology upgrades. The participant slot is blank for totally automated ISs. During the evolution of ISs and other WSs, the initiation, development, and implementation phases of the WSLC can be viewed as projects, i.e., work systems that ideally go out of existence after producing specific product/services. (Practices associated with agile development lead to a more nuanced view of topics touched by the WSLC.)

Special cases. The classification of WSs (including ISs) starts with a distinction between sociotechnical systems with human participants and totally automated systems that operate autonomously after being initiated or triggered. That is the top-level distinction because attributes of human participants are not relevant in totally automated WSs. Special cases of IS such as IS projects and information supply chains can be sociotechnical or totally automated. Each special case inherits concepts and other knowledge from more general cases and can have its own special cases, such as automated ISs based on machine learning or (sociotechnical) projects that produce customized software.

Facets. The TFIS recognizes facets of entire WSs (including entire ISs) or of elements of a WS (or IS). Facets identify significant aspects of a WS or of a WS element. For example, facets of processes and activities include making decisions, communicating, processing information, thinking, coordinating, and so on.

Portrayals. The TFIS recognizes portrayals as terms that apply to the entirety of a WS or WS element (in contrast with facets, which concern aspects of a WS or WS element). Alternative portrayals of the same WS or element are often useful when pursuing different purposes. Examples include portraying an IS as a sociotechnical system or as a tool that is used, portraying processes as specifications for how work will be performed vs. as guidelines for how work should be performed, and portraying information as meanings that inform people vs. as digital objects.

Functions. The TFIS recognizes that WSs may perform a variety of generic functions that contribute to their own operation or to the operation of WSs that they support, some of which may be ISs. Functions performed by ISs range from functions that are most directly associated with ISs such as providing information and collecting information through many other functions that apply to some ISs but not to many other ISs. Examples include enforcing rules for collecting and sharing information, controlling the sequence of workflows, controlling execution, suggesting decisions, producing alarms when specific conditions occur, triggering automated activities, and performing automated activities. WSs that are not ISs may perform those functions and many other functions that are not focused on information.

Overlaps. The TFIS recognizes that ISs and other WSs often overlap with other WSs that play roles in their operation, as when many ISs support or serve as integral components of other IT-enabled WSs. Different forms of overlap between ISs or WSs include interactions through a simple interface, separation or minimal overlap, significant overlap, and enclosure of one WS by another WS.

Attributes of Entities	***Characteristics, Performance variables, Phenomena***

The TFIS recognizes that frequently important attributes of entire WSs and of their elements include characteristics, performance variables (measured using metrics), and relevant phenomena. Many common examples of each type are associated with WSs as a whole and with individual WS elements. Characteristics are like adjectives that describe inherent properties. Performance variables identify measurable results that can be monitored and evaluated (usually periodically) by comparison with goals. Phenomena describe aspects of a WS's structure or operation that are neither inherent characteristics and nor performance variables.

Changes in State	***Events, Trajectories of change, Forces, Interactions***

Events. The TFIS recognizes that the operation of ISs (and other WSs) inherently involves events that change the status of the IS, its elements, and other resources that are relevant to its operation and to the operation of related WSs. Events occur at a specific point in time or over a time interval. Events may result from intentions or accidents and may be beneficial, neutral, or harmful. Many events are defined in relation to the start or completion of specific activities or occurrences during the operation and/or evolution of an IS.

Trajectories of change. Trajectories of change in the TFIS are sequences of events that are important in the operation and evolution of ISs (and other WSs). The work system life cycle model (WSLC) summarizes a trajectory of planned change encompassing initiation, development, and implementation phases leading to operation and maintenance of a new or improved WS (or IS). It also recognizes the importance of unplanned change through adaptations and workarounds.

Forces. The TFIS recognizes that at least five types of forces encourage or discourage changes in ISs (and WSs) as a whole. These include cohesive forces, disruptive forces, innovative forces, inertial forces, and forces at a distance. Factors related to elements of the work system framework frequently can be seen separately as drivers or impediments to change.

Interactions. The TFIS recognizes interactions between WSs (which may be ISs). An interaction is a specific occurrence, impact, or influence whereby one entity affects another (a one-way interaction) or two or more entities affect one another (two-way or multi-directional interaction). Interactions between separate WSs and between sub-systems of those WSs are essential for the operation of any enterprise, organization, business ecosystem, or IT-enabled system. Interactions also bring significant risks related to intentional and unintentional conditions or occurrences.

Generalizations	***Axioms, Principles, Theories, Frameworks, Models, Methods***

Axioms, Principles, Theories, Frameworks, Models, Methods. The TFIS contains generalizations but part of its larger purpose is to serve as a basis for generalizations that apply within its domain regardless of whether they are viewed as part of the TFIS. The work system framework and work system life cycle model are considered part of the TFIS. More elaborated versions of those generalizations might be considered part of the TFIS. Directly related generalizations that build on the TFIS can be considered separate from it. These may include axioms, principles, theories, frameworks, models, methods, and other types of that build on the TFIS and are useful for attaining value from using it.

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Attributes of Entities … Characteristics, Performance variables, Phenomena

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