Socio-technical Systems

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Though there are a few specific definitions, there are many ways in which the term “socio-technical system” is used depending on the specific engineering/scientific domain. There are also different approaches for considering socio-technical systems depending on the life cycle stage and the specific systems engineering challenge.

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Contents

The Concept and Theory

The concept of a socio-technical system describes the interrelationship between humans and machines, and the motivation behind developing research on socio-technical systems was to cope with theoretical and practical work environment problems in industry (Ropohl, 1999).

Socio-technical systems theory has been developing over the past 60 years predominately focusing on new technology and work design (Davis et al., 2014). This

theory has developed into socio-technical systems thinking, and research has concentrated in several key areas:

- Human factors and ergonomics (Carayon, 2006)
- Organizational design (Cherns, 1976)
- System design (Clegg, 2000; van Eijnatten, 1998)
- Information systems (Mumford, 2006)

A Design Approach

As a design approach —socio-technical systems design (STSD)—socio-technical systems bring human, social, organizational and technical elements in the design of organizational systems (Baxter and Sommerville, 2011). While Baxter and Sommerville (2011) refer to computer-based systems in their definition of socio-technical systems thinking as a design approach, the generic term "technical system" is also applicable: "The underlying premise of socio-technical systems thinking is that system design should be a process that takes into account both social and technical factors that influence the functionality and usage of computer-based systems" (p.4).

Systems Engineering Context

In a systems engineering context, it has been argued that all systems are socio-technical systems (Palmer, et al., 2019). However, socio-technical systems in a systems engineering context is not well defined though the topic has gained traction in recent years (Donaldson, 2017; Broniatowski, 2018). There are examples in systems engineering literature, where the term socio-technical systems is used to refer to a system where social and technical elements are relevant. These include studies of agent-based modeling of socio-technical systems (Heydari and Pennock, 2018), insurance systems as socio-critical systems (Yasui, 2011) and interdisciplinary systems engineering approaches to influence enterprise systems (Pennock and Rouse, 2016; Wang et al., 2018).

Based on the work that the systems engineering community has produced thus far, the working definition of the term socio-technical systems in a systems engineering context is simply:

Socio-technical systems: Systems operating at the intersection of social and technical systems (Kroes et al., 2006).

Modeling Sociotechnical Systems

There is no “state of the practice” for how to model sociotechnical systems. There are, however, a few examples in systems engineering literature of how systems engineers could analyze these types of systems. Outside systems engineering/engineering literature, there is an ever-increasing number of examples of social system models. The modeling techniques found in these examples can be adapted to evaluate sociotechnical systems in a systems engineering context. Many of these are system dynamics models, and there is a journal dedicated to social system analysis, called the Journal for Artificial Societies and Social Simulation (JASS), which focuses on agent-based modeling.

1) Qualitative Modeling

- Insurance systems as socio-critical systems (Yasui, 2011)

Yasui (2011) provides a new methodology to accommodate stakeholder goals in social system failures. This new methodology is a “soft” systems approach that brings together the Holon concept by Checkland and Scholes (1990) and the Vee Model.

2) Agent-Based Modeling of Sociotechnical Systems in Systems Engineering

- Agent-based modeling of sociotechnical systems (Heydari and Pennock, 2018)

Heydari and Pennock (2018) illustrate how to support the design and governance of sociotechnical systems with agent-based modeling (ABM). Critically, they outline the difference between how ABM is used in physical, natural and social applications versus sociotechnical applications.

- Interdisciplinary systems engineering approaches to influence enterprise systems (Pennock and Rouse, 2016)

Pennock and Rouse (2016) not only provide how to define an enterprise as a system, but they also illustrate this with several ABM examples. They also highlight that when modeling sociotechnical systems versus traditional engineering systems, it is important to focused less on “control” and more on “influence.”

3) Economic modeling

- Social System Modeling Challenges (Wang et al., 2018)

In their book, Social Systems Engineering, Wang et al. (2018) provide an overview of not only modeling and its challenges in evaluating social systems, but they also give insight into how social system modeling is approached in economics.

4) System Dynamics Modeling of Social Systems for Adaptation in an SE Sociotechnical Context

- Social policy (Palmer, 2017)

Palmer (2017) provides an overview of social systems in a systems engineering context, and uses system dynamics modeling of pension and sick leave policy systems to illustrate how to use systems engineering methods for social policy.

- Social Systems Engineering (García-Díaz and Olaya, 2018)

García-Díaz and Olaya (2018) give not only a thorough overview in their book (called Social Systems Engineering) of social systems and various qualitative and quantitative modeling types, but they also highlight participatory system dynamics modeling (stakeholder-led system design).

- Health care (Homer and Hirsch, 2006)

As there is increasing attention in the systems engineering community towards health care technology, Homer and Hirsch's (2006) paper on system dynamics modeling of public health gives a basis for how to model social systems in this domain. For example, chronic disease prevention, disease outcomes, health and risk behaviors, environmental factors, and health-related resources and delivery systems.

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Primary References

None.

Additional References

None.

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