

Conceptual Analysis of the Complexity of Socio-technical Systems

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Keywords: infrastructure, socio-technical system, modal constraints.

Infrastructure typically divides into transportation, energy supply and telecommunications. We wish to make two claims. First, it is both conceptually enlightening and of pragmatic import to construe infrastructural objects as *socio-technical systems*. Second, socio-technical systems are irreducible either to purely social or purely technical systems. Nor can they be factored out into either of them in the final analysis. Thus, we are going to introduce a conceptual category of inherently hybrid systems *sui generis*. This conception of system is somewhat more inclusive than other approaches to large-scale technical systems by incorporating not only technology and agents (whether individuals or groups) but also legislation and social conventions into the system.

The two fundamental questions of our research are:

- What is the character and degree of the *complexity* of a socio-technical system?
- How, if possible, are the *boundaries* of a socio-technical system to be delineated?

We suggest calibrating the complexity of a socio-technical system by means of the formal distinction between operations and factors or elements amenable to the operations. Our thesis is that a system boasting two operations is more complex than a system boasting only one, regardless of the quantity of elements the operation applies to. These operations are subject to various modal constraints, namely what is possible or necessary legally, conventionally, technologically, nomologically and logically speaking. Socio-technical systems are bound to contain various operations that are subject to various kinds of constraints, thereby increasing the complexity of the system.

By exceeding the boundaries of what normally passes for a technical system, it becomes less than obvious exactly how to redraw them. A socio-technical system is one that contains several subsystems and is at the same time itself a subsystem of larger systems. Our research is directed toward rigorously defining the notion of socio-technical system and demarcating, in a principled manner, any given such system. It is crucial to do so, not least because engineers are participate in designing, constructing, controlling, maintaining, mending and improving such systems and need to know what falls within the system, and what factors impact the functioning of the system in what ways.

We will use air transportation as a paradigmatic example of a socio-technical system. Air transportation is an input/output system that transforms a highly diversified pool of resources into the facilitation of the switchover between air and ground transportation and transfer between any two airports considered as nodes of the air transportation network. This system could not possibly perform this kind of transformation and transfer without a multitude of technological, societal, social and legal parameters being operational.

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