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Resilience in Sociotechnical Systems: The Perspectives of Multiple Stakeholders

Abstract We often design sociotechnical systems with the explicit intention that they will exhibit "resilience" in the face of unpredictable change. But there is often great uncertainty about how to define resilience – or achieve it. This article explores what design can learn about resilience by eliciting, combining, and contrasting multiple stakeholder perspectives within a single sociotechnical system. During one-on-one interviews, we asked participants to structure their ideas about resilience into a map of the overall system they work within. The maps were then used to analyze the system according to three key resilience characteristics. We found that the nature of their viewpoints was influenced by their ideas about the system's boundaries, purpose, and timescale. Our findings give rise to a better understanding of the nature of change in sociotechnical systems and how to design for their resilience.

Keywords
Resilience
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Introduction

Interest in the design challenges associated with sociotechnical systems has surged among design practitioners and academics in recent years.[1] Sociotechnical systems are often large and complex – public service, healthcare, and transportation, for example – and often span the boundaries dividing domains. Their success depends on interactions between technical and social subsystems, and thus a systems approach will reveal more about their structure and behavior than would examining the technical aspects or the human aspects alone.

If you asked any stakeholder in a sociotechnical system if they want that system to survive and thrive in times of uncertainty and change, they would undoubtedly say, "Yes!" But articulating what the characteristics of a resilient system are is difficult – let alone determining how that system could be better designed. This is true not only because resilience is defined differently in different domains. It is also linked to another set of concepts – including robustness, recovery, and adaptability – that are often poorly defined.

The systems we want to be strong, yet flexible, are most often complex, with interconnected subsystems that are both technical and social in nature. Even if we might be able to model and predict the behavior of a single technical or social subsystem, it is normally not possible to accurately predict the behavior of the sociotechnical system as a whole – not with the level of precision we seek. In addition, sociotechnical systems often have multiple stakeholders who have different perspectives on what the system's essential purpose and structure is. For all these reasons, if we want to design better systems, we need a systems design approach.

To achieve an understanding of resilience in design practice, we elicited feedback from multiple stakeholders in a single sociotechnical system: a development and infrastructure project at a leading European university. This involved a series of one-to-one interviews, each of which included a system mapping exercise. The mapping exercise served to structure their ideas about the system and its resilience. This article reports the findings from that study, and explores what we can learn about resilience by eliciting, combining, and contrasting multiple stakeholder perspectives within a single sociotechnical system. This research provides some understanding of how to frame individual stakeholders' perspectives on resilience within the same sociotechnical system. We hope that this will help those designing sociotechnical systems to more effectively engage with relevant stakeholders, structuring those engagements in a way that explores the many concepts that collectively define resilience.

Literature Review

In order to develop a framework for our conversations about resilience with the stakeholder participants, we first looked across the literature to identify a) the core characteristics of resilience, and b) proven approaches to a study of complex sociotechnical systems.

Resilience across Domains

Our definition of word *resilience* originates from C. S. Holling's work with ecological and socio-ecological systems, where he defines it as the persistence of system relationships and the ability of a system to absorb external changes.[2] Engineered systems are designed to reliably perform specific tasks with predictable external influences, but ecological systems must persist when confronting extreme change and uncertainty despite that lack of stability.[3] In the ecological resilience literature, systems that change over time are described using the adaptive cycle model.[4] Continuous cycles of change happen at different levels within a system – change at one

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2 Crawford S. Holling, "Resilience and Stability of Ecological Systems," *Annual Review of Ecology and Systematics* 4, no. 1 (1973): 1–23, DOI: https://doi.org/10.1146/annurev.es.04.110173.000245.

3 Crawford S. Holling, "Engineering Resilience versus Ecological Resilience," in *Engineering Within Ecological Constraints*, ed. Peter C. Schulze (Washington, DC: National Academy Press, 1996), 31–43.

4 Lance H. Gunderson and Crawford S. Holling, eds., *Panarchy: Understanding Transformations in Human and Natural Systems* (Washington: Island Press, 2001).