

Preface

Complex systems play an increasingly important role in the advancement of numerous technologies and even in the conduct of our daily lives. The development and support of these systems is challenged by several factors. We continue to push the limits of hardware and software to deliver greater performance, sometimes at the risk of failures that can quickly become catastrophic. New technical disciplines, such as cyber security, are being integrated into legacy and emerging systems, while subsystems are gaining in both complexity and interdependency. Local control systems interact directly, and sometimes autonomously, with global command and control centers. High tech sensors and feedback loops are embedded in all levels of components to enhance capability, but their effects are not always fully understood or characterized by the product designers.

Traditional systems engineering approaches provide a general methodology, but often break down when applied to systems so complex that it is not possible to fully characterize all of the subsystems under all potential conditions. Contributing elements include the remoteness and extremity of the actual operating environment, the inability to integrate with critical infrastructure during development due to considerations for safety and security, the unpredictability of human interfaces, or just the inexhaustible number of circuit and software logic paths of the system. Even as we bring on more high power computing and continue to advance modeling and simulation capabilities, there is no substitute for testing, early and often, but that approach often has limitations.

When failures occur or out of phase technical issues are discovered, the subsequent root cause analyses and corrective actions are often accompanied by investigations to determine where the process went wrong. Inevitably, breakdowns in the execution of the traditional systems engineering process discipline are identified, to which we respond by embedding more checklists, reviews, approvals, and analysis tools, as well as organizational changes, better communications, etc., all wrapped up with the promise to do better next time. The findings are real and there are always opportunities to improve our systems development; however, we should be

open to new techniques that supplement our conventional systems engineering methods to address the challenges of complex systems.

Not all of the opportunities will lie in traditional engineering disciplines. Research to replicate the evolution of biological systems has led to real applications for technical design. Embracing the power of social media through crowdsourcing is also proving to be a viable model for design development. There are many examples that demonstrate the innovations that can come from opening up our engineering aperture and looking to other fields of study for potential solutions.

This book casts a wide net in seeking out current work from multiple disciplines, each focused on advancing the state of complex systems development or management. There is growing consensus on the definitions and attributes, but not complete agreement. A number of researchers use the term “complex” to indicate a system that has, or is likely to have, emergent behavior, while there are still many practitioners who use “complex” in the generic English sense to mean “complicated” or “multifaceted.” Approaches to addressing system complexity range across technical and sociological foundations, resulting in numerous candidate models and methods—each offering an opportunity for solutions and increased understanding. Value comes from the open-minded consideration of these distinctly different perspectives. By presenting this wide scope of approaches, the editors hope to foster conversation, additional research, and overall advancement of the science of complex systems.

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Transdisciplinary Perspectives on Complex Systems

New Findings and Approaches

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2017, X, 327 p. 89 illus., 55 illus. in color., Hardcover

ISBN: 978-3-319-38754-3