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COMPLEX ENGINEERED SYSTEMS

SCIENCE MEETS TECHNOLOGY

Springer *This book sheds light on the large-scale engineering systems that shape and guide our everyday lives. It does this by bringing together the latest research and practice defining the emerging field of Complex Engineered Systems. Understanding, designing, building and controlling such complex systems is going to be a central challenge for engineers in the coming decades. This book is a step toward addressing that challenge.*

SAFETY AND RELIABILITY OF COMPLEX ENGINEERED SYSTEMS

ESREL 2015

CRC Press *Safety and Reliability of Complex Engineered Systems contains the Proceedings of the 25th European Safety and Reliability Conference, ESREL 2015, held 7-10 September 2015 in Zurich, Switzerland. It includes about 570 papers accepted for presentation at the conference. These contributions focus on theories and methods in the area of risk, safety and*

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COMPLEX SYSTEMS ENGINEERING

THEORY AND PRACTICE

LARGE-SCALE COMPLEX SYSTEM AND SYSTEMS OF SYSTEMS

John Wiley & Sons *With the growing maturity of information and communication technologies, systems have been interconnected within growing networks, yielding new services through a combination of the system functionalities. This leads to an increasing complexity that has to be managed in order to take advantage of these system integrations. This book provides key answers as to how such systems of systems can be engineered and how their complexity can be mastered. After reviewing some definitions on systems of systems engineering, the book focuses on concrete applications and offers a survey of the activities and techniques that allow engineering of complex systems and systems of systems. Case studies, ranging from emergency situations such as Hurricane Katrina and its crisis management or a generic scenario of a major traffic accident and its emergency response, to the establishment of a scientific basis in the Antarctic region illustrate key factors of success and traps to avoid in order to cope with such situations.*

DESIGNING COMPLEX SYSTEMS

FOUNDATIONS OF DESIGN IN THE FUNCTIONAL DOMAIN

CRC Press *Without standardized construction elements such as nuts, bolts, bearings, beams, resistors and the like, the design of physical equipment is hopelessly inefficient, and engineers are continually bogged down with re-designing these elements over and over again. The same can be said for the domain of ideas and performance requirements. Only through a process of standardization of the corresponding functional elements will systems engineering truly live up to its potential of increased efficiency and quality.*

Designing Complex Systems: Foundations of Design in the Functional Domain introduces students and practitioners in the field of system design to a particular methodology that addresses design issues in a rigorous and consistent top-down fashion. It also reassesses the characteristics of engineering and its place within the field of intellectual activity, in particular, examining the creative aspects of design as reflected in the difference between engineers and technicians. Erik W. Aslaksen brings forty years of experience to the table with this groundbreaking work. He examines how the concept of value can provide a quantitative measure of that wider interaction of the engineered object with its environment. With its forward-looking approach and holistic perspective, this volume is sure to advance the field of knowledge of systems engineering for years to come.

A FRAMEWORK FOR ASSESSING AND IMPROVING THE RESILIENCE OF COMPLEX ENGINEERED SYSTEMS DURING THE EARLY DESIGN PROCESS

As modern systems continue to increase in size and complexity, they pose significant safety and risk management challenges. System engineers and much of the government research efforts are focused on understanding the attributes and characteristics that emerge from the interactions of components and subsystems. As a result, the objective of this research is to develop techniques and supporting tools for the verification of the resilience of complex engineered systems during the early design stages. Specifically, this work focuses on automating the verification of safety requirements to ensure designs are safe, automating the analysis of design topology to increase design robustness against internal failures or external attacks, and allocating appropriate level of redundancy into the design to ensure designs are resilient. In distributed complex systems, a single initiating fault can propagate throughout engineering systems uncontrollably, resulting in severely degraded performance or complete failure. This research is motivated by the fact that there is no formal means to verify the safety and resilience properties, and no provision to incorporate related analysis into the design process.

MODELING AND CONTROL OF COMPLEX SYSTEMS

CRC Press *Comprehension of complex systems comes from an understanding of not only the behavior of constituent elements but how they act together to form the behavior of the whole. However, given the multidisciplinary nature of complex systems, the scattering of information across different areas creates a chaotic situation for those trying to understand possible solutions and applications. Modeling and Control of Complex Systems brings together a number of research experts to present some of their latest approaches and future research directions in a language accessible to system theorists. Contributors discuss complex systems such as networks for modeling and control of civil structures, vehicles, robots, biomedical systems, fluid flow systems, and home automation*

systems. Each chapter provides theoretical and methodological descriptions of a specific application in the control of complex systems, including congestion control in computer networks, autonomous multi-robot docking systems, modeling and control in cancer genomics, and backstepping controllers for stabilization of turbulent flow PDEs. With this unique reference, you will discover how complexity is dealt with in different disciplines and learn about the latest methodologies, which are applicable to your own specialty. The balanced mix of theory and simulation presented by *Modeling and Control of Complex Systems* supplies a strong vehicle for enlarging your knowledge base a fueling future advances and incredible breakthroughs.

FAULT DIAGNOSIS AND PROGNOSIS TECHNIQUES FOR COMPLEX ENGINEERING SYSTEMS

Elsevier *Fault Diagnosis and Prognosis Techniques for Complex Engineering Systems* gives a systematic description of the many facets of envisaging, designing, implementing, and experimentally exploring emerging trends in fault diagnosis and failure prognosis in mechanical, electrical, hydraulic and biomedical systems. The book is devoted to the development of mathematical methodologies for fault diagnosis and isolation, fault tolerant control, and failure prognosis problems of engineering systems. Sections present new techniques in reliability modeling, reliability analysis, reliability design, fault and failure detection, signal processing, and fault tolerant control of engineering systems. Sections focus on the development of mathematical methodologies for diagnosis and prognosis of faults or failures, providing a unified platform for understanding and applicability of advanced diagnosis and prognosis methodologies for improving reliability purposes in both theory and practice, such as vehicles, manufacturing systems, circuits, flights, biomedical systems. This book will be a valuable resource for different groups of readers - mechanical engineers working on vehicle systems, electrical engineers working on rotary machinery systems, control engineers working on fault detection systems, mathematicians and physician working on complex dynamics, and many more. Presents recent advances of theory, technological aspects, and applications of advanced diagnosis and prognosis methodologies in engineering applications Provides a series of the latest results, including fault detection, isolation, fault tolerant control, failure prognosis of components, and more Gives numerical and simulation results in each chapter to reflect engineering practices

ENGINEERING SYSTEMS

MEETING HUMAN NEEDS IN A COMPLEX TECHNOLOGICAL WORLD

MIT Press *An overview of engineering systems that describes the new challenges posed for twenty-first-century engineers by today's highly complex sociotechnical systems. Engineering, for much of the twentieth century, was mainly about artifacts and inventions. Now, it's increasingly about complex systems. As the airplane taxis to the gate, you access the Internet and check email with your*

PDA, linking the communication and transportation systems. At home, you recharge your plug-in hybrid vehicle, linking transportation to the electricity grid. Today's large-scale, highly complex sociotechnical systems converge, interact, and depend on each other in ways engineers of old could barely have imagined. As scale, scope, and complexity increase, engineers consider technical and social issues together in a highly integrated way as they design flexible, adaptable, robust systems that can be easily modified and reconfigured to satisfy changing requirements and new technological opportunities. Engineering Systems offers a comprehensive examination of such systems and the associated emerging field of study. Through scholarly discussion, concrete examples, and history, the authors consider the engineer's changing role, new ways to model and analyze these systems, the impacts on engineering education, and the future challenges of meeting human needs through the technologically enabled systems of today and tomorrow.

DECENTRALIZED CONTROL OF COMPLEX SYSTEMS

Academic Press *Decentralized Control of Complex Systems*

COMPLEX ENGINEERING SERVICE SYSTEMS

CONCEPTS AND RESEARCH

Springer Science & Business Media *For manufacturers of complex engineering equipment, the focus on service and achieving outcomes for customers is the key to growth. Yet, the capability to provide service for complex engineered products is less understood. Taking a trans-disciplinary approach, Complex Engineering Service Systems covers various aspects of service in complex engineering systems, with perspectives from engineering, management, design, operations research, strategy, marketing and operations management that are relevant to different disciplines, organisation functions, and geographic locations. The focus is on the many facets of complex engineering service systems around a core integrative framework of three value transformations - that of material/equipment, information and people. Complex Engineering Service Systems is the outcome of the EPSRC/BAE Systems S4T (Service Support Solutions: Strategy and Transition) research programme of 10 universities and 27 researchers, which examined how high-value manufacturers of complex engineering products adapt to a multi-partnered environment to design and deliver value in a service system. Complex Engineering Service Systems aims to be the main source of knowledge for academics and professionals in the research and practice of contracting, managing, designing, leading, and delivering complex engineering service systems. The book takes a value-based approach to integrating equipment and human factors into a total service provision. In doing so, it aims to advance the field of service systems and engineering.*

DESIGN OF COMPLEX ENGINEERED SYSTEMS AND THE EFFECTIVENESS OF ORGANIZATIONAL NETWORKS

INTRODUCTION TO HUMANS IN ENGINEERED SYSTEMS

John Wiley & Sons Fully up-to-date coverage of human factors engineering—plus online access to interactive demonstrations and exercises Engineering accomplishments can be as spectacular as a moon landing or as mundane as an uneventful drive to the local grocery store. Their failures can be as devastating as a plane crash or a massive oil spill. Over the past decade, psychologists and engineers have made great strides in understanding how humans interact with complex engineered systems—human engineering. *Introduction to Humans in Engineered Systems* provides historical context for the discipline and an overview of some of the real-world settings in which human engineering has been successfully applied, including aviation, medicine, computer science, and ground transportation. It presents findings on the nature and variety of human-engineering environments, human capabilities and limitations, and how these factors influence system performance. Important features include: Contents organized around the interaction of the human operator with the larger environment to guide the analysis of real-world situations A web-based archive of interactive demonstrations, exercises, and links to additional readings and tools applicable to a range of application domains Web content customizable for focus on particular areas of study or research

COMPLEX SYSTEMS SCIENCE IN BIOMEDICINE

Springer Science & Business Media *Complex Systems Science in Biomedicine* Thomas S. Deisboeck and J. Yasha Kresh *Complex Systems Science in Biomedicine* covers the emerging field of systems science involving the application of physics, mathematics, engineering and computational methods and techniques to the study of biomedicine including nonlinear dynamics at the molecular, cellular, multi-cellular tissue, and organismic level. With all chapters helmed by leading scientists in the field, *Complex Systems Science in Biomedicine's* goal is to offer its audience a timely compendium of the ongoing research directed to the understanding of biological processes as whole systems instead of as isolated component parts. In Parts I & II, *Complex Systems Science in Biomedicine* provides a general systems thinking perspective and presents some of the fundamental theoretical underpinnings of this rapidly emerging field. Part III then follows with a multi-scaled approach, spanning from the molecular to macroscopic level, exemplified by studying such diverse areas as molecular networks and developmental processes, the immune and nervous systems, the heart, cancer and multi-organ failure. The volume concludes with Part IV that addresses methods and techniques driven in design and development by this new understanding of biomedical science. Key Topics Include: • Historic Perspectives of General Systems Thinking • Fundamental Methods and Techniques for Studying Complex Dynamical Systems • Applications from Molecular Networks to

Disease Processes • Enabling Technologies for Exploration of Systems in the Life Sciences Complex Systems Science in Biomedicine is essential reading for experimental, theoretical, and interdisciplinary scientists working in the biomedical research field interested in a comprehensive overview of this rapidly emerging field. About the Editors: Thomas S. Deisboeck is currently Assistant Professor of Radiology at Massachusetts General Hospital and Harvard Medical School in Boston. An expert in interdisciplinary cancer modeling, Dr. Deisboeck is Director of the Complex Biosystems Modeling Laboratory which is part of the Harvard-MIT Martinos Center for Biomedical Imaging. J. Yasha Kresh is currently Professor of Cardiothoracic Surgery and Research Director, Professor of Medicine and Director of Cardiovascular Biophysics at the Drexel University College of Medicine. An expert in dynamical systems, he holds appointments in the School of Biomedical Engineering and Health Systems, Dept. of Mechanical Engineering and Molecular Pathobiology Program. Prof. Kresh is Fellow of the American College of Cardiology, American Heart Association, Biomedical Engineering Society, American Institute for Medical and Biological Engineering.

EMERGENT BEHAVIOR IN COMPLEX SYSTEMS ENGINEERING

A MODELING AND SIMULATION APPROACH

John Wiley & Sons *A comprehensive text that reviews the methods and technologies that explore emergent behavior in complex systems engineering in multidisciplinary fields In Emergent Behavior in Complex Systems Engineering, the authors present the theoretical considerations and the tools required to enable the study of emergent behaviors in manmade systems. Information Technology is key to today's modern world. Scientific theories introduced in the last five decades can now be realized with the latest computational infrastructure. Modeling and simulation, along with Big Data technologies are at the forefront of such exploration and investigation. The text offers a number of simulation-based methods, technologies, and approaches that are designed to encourage the reader to incorporate simulation technologies to further their understanding of emergent behavior in complex systems. The authors present a resource for those designing, developing, managing, operating, and maintaining systems, including system of systems. The guide is designed to help better detect, analyse, understand, and manage the emergent behaviour inherent in complex systems engineering in order to reap the benefits of innovations and avoid the dangers of unforeseen consequences. This vital resource: Presents coverage of a wide range of simulation technologies Explores the subject of emergence through the lens of Modeling and Simulation (M&S) Offers contributions from authors at the forefront of various related disciplines such as philosophy, science, engineering, sociology, and economics Contains information on the next generation of complex systems engineering Written for researchers, lecturers, and students, Emergent Behavior in Complex Systems Engineering provides an overview of the current discussions on complexity and emergence, and shows how systems engineering methods in general and simulation methods in*

particular can help in gaining new insights in complex systems engineering.

INTRODUCTION TO COMPLEXITY AND COMPLEX SYSTEMS

CRC Press *The boundaries between simple and complicated, and complicated and complex system designations are fuzzy and debatable, even using quantitative measures of complexity. However, if you are a biomedical engineer, a biologist, physiologist, economist, politician, stock market speculator, or politician, you have encountered complex systems. Furthermore, your success depends on your ability to successfully interact with and manage a variety of complex systems. In order not to be blindsided by unexpected results, we need a systematic, comprehensive way of analyzing, modeling, and simulating complex systems to predict non-anticipated outcomes. In its engaging first chapters, the book introduces complex systems, Campbell's Law, and the Law of Unintended Consequences, and mathematics necessary for conversations in complex systems. Subsequent chapters illustrate concepts via commonly studied biological mechanisms. The final chapters focus on higher-level complexity problems, and introduce complexity in economic systems. Designed as a reference for biologists and biological engineers, Introduction to Complexity and Complex Systems lends itself to use in a classroom course to introduce advanced students studying biomedical engineering, biophysics, or physiology to complex systems. Engaging and illustrative, this book aids scientists and decision makers in managing biological complexity and complex systems.*

MANAGING COMPLEX SYSTEMS

THINKING OUTSIDE THE BOX

John Wiley & Sons *Nine innovative methods to think outside the box and solve complex system problems* *Managing Complex Systems* provides specific tools and guidance needed to be a more creative and innovative thinker. Following the author's methodology, the reader will be better able to devise and implement nontraditional solutions to seemingly intractable complex problems. By challenging the reader to think in new and creative ways, the book offers a road map to success, whether measured in terms of competitive advantage, greater market share, improved productivity, or higher profits, all based upon better solutions to difficult problems. The first four chapters set the foundation for creative thinking by exploring the nature of large-scale systems and complexity, thinking inside and outside the box, and examples of how an inventive mind solves problems in both management and scientific domains. Subsequent chapters address nine focused methods that the author has formulated to help the reader think outside the box: * Broaden and generalize * Crossover * Question conventional wisdom * Back of the envelope * Expanding the dimensions * Obversity * Remove constraints * Thinking with pictures * Systems approach Real-life examples are provided for each

method that demonstrate how the approach enhances problem solving and decision making in system development and management. Following the discussion of the nine methods, the author examines group decision making as well as additional creative thinking procedures devised by other researchers, including references that assist in exploring these methods in greater detail. The author ends with a wrap-up chapter that includes a test to help readers practice their tendencies toward creative thinking skills and action with respect to solving real-world problems. The nine methods discussed in this book have broad applicability and can be used successfully by managers with a wide range of responsibilities in business and technology. For anyone who is tired of the same old approach with the same old results, this book is essential reading.

MODEL-ORIENTED SYSTEMS ENGINEERING SCIENCE

A UNIFYING FRAMEWORK FOR TRADITIONAL AND COMPLEX SYSTEMS

CRC Press *Systems engineering (SE) is experiencing a significant expansion that encompasses increasingly complex systems. However, a common body of knowledge on how to apply complex systems engineering (CSE) has yet to be developed. A combination of people and other autonomous agents, crossing organization boundaries and continually changing, these hybrid systems are less predictable while being more self-organizing and adaptive than traditional systems. The growing pains of this evolution and the ever-widening reach of SE technology require an effective foundation for integrating traditional and complex engineering methods, addressing machine and human interaction, as well as scaling up and down, from nano scale to the macro system-of-systems level. Model-oriented Systems Engineering Science: A Unifying Framework for Traditional and Complex Systems addresses solutions to that expansion and integration problem. This text takes advantage of better-understood systems science (SS) to support the transition, identifying and using commonalities between complex systems and other sciences, such as biology, sociology, cognitive science, organizational theory, and computational science. The author defines Model-oriented Systems Engineering Science (MOSES), an organized system that selects appropriate information from these disciplines and unifies it into a coherent framework. The result is a seamless approach to the class of systems across the extended scope of the new SE—a foundation upon which to develop an enhanced and unified SE. Modeling orientation (MO) provides a common perspective on the entire SES/SE enterprise, including all supporting sciences, engineering for the full range of traditional, complex, and hybrid systems, and their management. This book extends existing modeling approaches into an MO that views all science artifacts and engineering artifacts as models of systems. It organizes them into a virtual structured repository called the "SE model space"—effectively a container for the accumulating body of SE and SES knowledge in the form of models and patterns. By organizing and integrating all these elements into a common framework, the author makes the material not only easily accessible but also immediately applicable, and provides a well-grounded*

basis for future growth and evolution of the SE discipline.

ENTERPRISE DYNAMICS SOURCEBOOK

CRC Press *Rapidly changing market, technological, and organizational environments are forcing government and private sector enterprises to improve services and transform processes. Employing a case study approach, the Enterprise Dynamics Sourcebook presents frameworks and analytical models of the enterprise as a complex system to improve your understanding of its dynamic elements and their interactions. Illustrating the transformation environments and the evolution of methods required to address emerging challenges, this sourcebook is the product of MITRE-sponsored research on enterprise dynamics and the range of applications pertaining to enterprise transformation programs. It explains how to address the complexities involved with the coordination of policies, organizations, economics, and technology (POET) in operational strategies and processes. It also: Presents qualitative and quantitative data-analytic methods including process workflow, systems dynamics, and highly optimized tolerance-inspired models of SoSE processes Features Bayesian probability and state-space transition methods to address uncertainties in the controlled, influenced, and uncontrolled aspects of enterprise dynamics Explains how to use hybrid multi-scale modeling coupled with enterprise architecture to support decision making in the design, acquisition, and management of complex transformation efforts Outlines methods applicable in the national security, aviation, nuclear waste processing, international commerce, energy and materials, and healthcare sectors of the U.S. economy The structures and concepts covered in this book will be useful to managers and technical staff in government entities as well as private sector enterprises with significant operational and regulatory interaction with government entities. The enterprise dynamics methods discussed can help in the advancement of systems engineering practices at the enterprise level and also enable the enterprise systems engineering and architecting (ESE/A) process. Filled with examples, the text provides the understanding of the qualitative and quantitative data-analytic methods required to reduce risk and failure rates and enable your organization to operate effectively in today's complex and ever-changing environment.*

COMPLEX SYSTEM RELIABILITY

MULTICHANNEL SYSTEMS WITH IMPERFECT FAULT COVERAGE

Springer Science & Business Media *Complex System Reliability presents a state-of-the-art treatment of complex multi-channel system reliability assessment and provides the requisite tools, techniques and algorithms required for designing, evaluating and optimizing ultra-reliable redundant systems. Critical topics that make Complex System Reliability a unique and definitive resource include:*

- *redundant system analysis for k-out-of-n systems (including complex systems with embedded k-out-of-n structures)*

involving both perfect and imperfect fault coverage; • imperfect fault coverage analysis techniques, including algorithms for assessing the reliability of redundant systems in which each element is subject to a given coverage value (element level coverage) or in which the system uses voting to avoid the effects of a failed element (fault level coverage); and • state-of-the-art binary decision diagram analysis techniques, including the latest and most efficient algorithms for the reliability assessment of large, complex redundant systems. This practical presentation includes numerous fully worked examples that provide detailed explanations of both the underlying design principles and the techniques (such as combinatorial, recursive and binary decision diagram algorithms) used to obtain quantitative results. Many of the worked examples are based on the design of modern digital fly-by-wire control system technology. Complex System Reliability provides in-depth coverage of systems subject to either perfect or imperfect fault coverage and also the most recent techniques for correctly assessing the reliability of redundant systems that use mid-value-select voting as their primary means of redundancy management. It is a valuable resource for those involved in the design and reliability assessment of highly reliable systems, particularly in the aerospace and automotive sectors.

DESIGNING COMPLEX PRODUCTS WITH SYSTEMS ENGINEERING PROCESSES AND TECHNIQUES

CRC Press *This book looks at how to design complex products that have many components with intricate relationships and requirements. It also discusses how to manage processes involved in their lifecycle, from concept generation to disposal, with the objectives of increasing customer satisfaction, quality, safety, and usability and meeting program timings and budgets. Part I covers systems engineering concepts, issues, and bases in product design. Part II examines quality, human factors, and safety engineering approaches. Part III describes important tools and methods used in these fields, and Part IV includes other relevant integration topics, interesting applications of useful techniques, and observations from a few "landmark" product development case studies.*

SYSTEMS ENGINEERING FOR PROJECTS

ACHIEVING POSITIVE OUTCOMES IN A COMPLEX WORLD

CRC Press *Systems engineering has been applied to some of the most important projects of our time, including those that have helped humanity explore the world and the universe, expand our technical abilities, and enhance the quality of human life. Without formal training in systems engineering, the discipline is often difficult to understand and apply, and its use within projects is often confusing. Systems Engineering for Projects: Achieving Positive Outcomes in a Complex World provides an approach that utilizes a combination of the most effective processes from both project management and systems engineering disciplines in a simplified and straightforward manner. The processes described in the book are lightweight, flexible, and tailorable. They provide the shortest path*

to success in projects across the entire project life cycle, from research to operations, and from simple to the most complex. The book also addresses how this methodology can be used in a continually adapting and changing world, as projects span disciplines and become even more interconnected across all areas of human existence. Each chapter includes diagrams, templates, summary lists, a case study, and a thought-provoking question and answer section that assists readers in immediate application of the material to their own projects. The book is a project manager's resource for understanding how to directly apply essential processes to projects in a way that increases the probability of achieving success. It is a comprehensive, go-to manual on the application of systems engineering processes to projects of all types and complexity.

ARCHITECTURE AND PRINCIPLES OF SYSTEMS ENGINEERING

CRC Press *The rapid evolution of technical capabilities in the systems engineering (SE) community requires constant clarification of how to answer the following questions: What is Systems Architecture? How does it relate to Systems Engineering? What is the role of a Systems Architect? How should Systems Architecture be practiced? A perpetual reassessment of concepts and practices is taking place across various systems disciplines at every level in the SE community. Architecture and Principles of Systems Engineering addresses these integral issues and prepares you for changes that will be occurring for years to come. With their simplified discussion of SE, the authors avoid an overly broad analysis of concepts and terminology. Applying their substantial experience in the academic, government, and commercial R&D sectors, this book is organized into detailed sections on: Foundations of Architecture and Systems Engineering Modeling Languages, Frameworks, and Graphical Tools Using Architecture Models in Systems Analysis and Design Aerospace and Defense Systems Engineering Describing ways to improve methods of reasoning and thinking about architecture and systems, the text integrates concepts, standards, and terminologies that embody emerging model-based approaches but remain rooted in the long-standing practices of engineering, science, and mathematics. With an emphasis on maintaining conceptual integrity in system design, this text describes succinct practical approaches that can be applied to the vast array of issues that readers must resolve on a regular basis. An exploration of the important questions above, this book presents the authors' invaluable experience and insights regarding the path to the future, based on what they have seen work through the power of model-based approaches to architecture and systems engineering.*

CONTROL OF COMPLEX SYSTEMS

THEORY AND APPLICATIONS

Butterworth-Heinemann *In the era of cyber-physical systems, the area of control of complex systems has grown to be one of the*

hardest in terms of algorithmic design techniques and analytical tools. The 23 chapters, written by international specialists in the field, cover a variety of interests within the broader field of learning, adaptation, optimization and networked control. The editors have grouped these into the following 5 sections: "Introduction and Background on Control Theory", "Adaptive Control and Neuroscience", "Adaptive Learning Algorithms", "Cyber-Physical Systems and Cooperative Control", "Applications". The diversity of the research presented gives the reader a unique opportunity to explore a comprehensive overview of a field of great interest to control and system theorists. This book is intended for researchers and control engineers in machine learning, adaptive control, optimization and automatic control systems, including Electrical Engineers, Computer Science Engineers, Mechanical Engineers, Aerospace/Automotive Engineers, and Industrial Engineers. It could be used as a text or reference for advanced courses in complex control systems. • Collection of chapters from several well-known professors and researchers that will showcase their recent work • Presents different state-of-the-art control approaches and theory for complex systems • Gives algorithms that take into consideration the presence of modelling uncertainties, the unavailability of the model, the possibility of cooperative/non-cooperative goals and malicious attacks compromising the security of networked teams • Real system examples and figures throughout, make ideas concrete Includes chapters from several well-known professors and researchers that showcases their recent work Presents different state-of-the-art control approaches and theory for complex systems Explores the presence of modelling uncertainties, the unavailability of the model, the possibility of cooperative/non-cooperative goals, and malicious attacks compromising the security of networked teams Serves as a helpful reference for researchers and control engineers working with machine learning, adaptive control, and automatic control systems

DESIGN OF RESILIENT AND SUSTAINABLE COMPLEX ENGINEERED SYSTEMS

With the development of new complex engineered systems or retrofitting the old ones, new types of safety issues and unforeseen failure modes may have arisen. Traditional probabilistic risk assessment framework falls short in evaluating the risks involved in the unexpected adverse failure events, such as those major failures induced by nature. Focusing on failure prevention and recovery efforts, the concept of resilience provides a new way to cope with system complexity and failures. A resilient system is a system that possesses the ability to survive and recover from the likelihood of failures due to disruptive events. The design concept that incorporates resiliency into engineering practices is known as engineering resilience. Despite an increase in the usage of engineering resilience concept, the diversity of its applications in various engineering sectors complicates a universal agreement on its quantification and associated measurement techniques. Thus, there is a pressing need to develop a generally applicable engineering resilience analysis framework. This dissertation proposes enhanced predictive engineering resilience analysis frameworks, which include the modeling, assessment, allocation, and improvement in designing resilient systems for a broader engineering discipline.

The presented study also expects to serve as a building block toward developing resilient and sustainable complex engineered systems.

RESEARCH CHALLENGES IN MODELING AND SIMULATION FOR ENGINEERING COMPLEX SYSTEMS

Springer *This illuminating text/reference presents a review of the key aspects of the modeling and simulation (M&S) life cycle, and examines the challenges of M&S in different application areas. The authoritative work offers valuable perspectives on the future of research in M&S, and its role in engineering complex systems. Topics and features: reviews the challenges of M&S for urban infrastructure, healthcare delivery, automated vehicle manufacturing, deep space missions, and acquisitions enterprise; outlines research issues relating to conceptual modeling, covering the development of explicit and unambiguous models, communication and decision-making, and architecture and services; considers key computational challenges in the execution of simulation models, in order to best exploit emerging computing platforms and technologies; examines efforts to understand and manage uncertainty inherent in M&S processes, and how these can be unified under a consistent theoretical and philosophical foundation; discusses the reuse of models and simulations to accelerate the simulation model development process. This thought-provoking volume offers important insights for all researchers involved in modeling and simulation across the full spectrum of disciplines and applications, defining a common research agenda to support the entire M&S research community.*

PHILOSOPHY OF COMPLEX SYSTEMS

Elsevier *The domain of nonlinear dynamical systems and its mathematical underpinnings has been developing exponentially for a century, the last 35 years seeing an outpouring of new ideas and applications and a concomitant confluence with ideas of complex systems and their applications from irreversible thermodynamics. A few examples are in meteorology, ecological dynamics, and social and economic dynamics. These new ideas have profound implications for our understanding and practice in domains involving complexity, predictability and determinism, equilibrium, control, planning, individuality, responsibility and so on. Our intention is to draw together in this volume, we believe for the first time, a comprehensive picture of the manifold philosophically interesting impacts of recent developments in understanding nonlinear systems and the unique aspects of their complexity. The book will focus specifically on the philosophical concepts, principles, judgments and problems distinctly raised by work in the domain of complex nonlinear dynamical systems, especially in recent years. -Comprehensive coverage of all main theories in the philosophy of Complex Systems -Clearly written expositions of fundamental ideas and concepts -Definitive discussions by leading researchers in the field - Summaries of leading-edge research in related fields are also included*

CASE STUDIES IN SYSTEM OF SYSTEMS, ENTERPRISE SYSTEMS, AND COMPLEX SYSTEMS ENGINEERING

CRC Press Suitable as a reference for industry practitioners and as a textbook for classroom use, *Case Studies in System of Systems, Enterprise Systems, and Complex Systems Engineering* provides a clear understanding of the principles and practice of system of systems engineering (SoSE), enterprise systems engineering (ESE), and complex systems engineering (CSE). Multiple domain practitioners present and analyze case studies from a range of applications that demonstrate underlying principles and best practices of transdisciplinary systems engineering. A number of the case studies focus on addressing real human needs. Diverse approaches such as use of soft systems skills are illustrated, and other helpful techniques are also provided. The case studies describe, examine, analyze, and assess applications across a range of domains, including: Engineering management and systems engineering education Information technology business transformation and infrastructure engineering Cooperative framework for and cost management in the construction industry Supply chain modeling and decision analysis in distribution centers and logistics International development assistance in a foreign culture of education Value analysis in generating electrical energy through wind power Systemic risk and reliability assessment in banking Assessing emergencies and reducing errors in hospitals and health care systems Information fusion and operational resilience in disaster response systems Strategy and investment for capability developments in defense acquisition Layered, flexible, and decentralized enterprise architectures in military systems Enterprise transformation of the air traffic management and transport network Supplying you with a better understanding of SoSE, ESE, and CSE concepts and principles, the book highlights best practices and lessons learned as benchmarks that are applicable to other cases. If adopted correctly, the approaches outlined can facilitate significant progress in human affairs. The study of complex systems is still in its infancy, and it is likely to evolve for decades to come. While this book does not provide all the answers, it does establish a platform, through which analysis and knowledge application can take place and conclusions can be made in order to educate the next generation of systems engineers.

SYSTEMS ENGINEERING DEMYSTIFIED

A PRACTITIONER'S HANDBOOK FOR DEVELOPING COMPLEX SYSTEMS USING A MODEL-BASED APPROACH

Packt Publishing Ltd Get to grips with systems engineering life cycles, processes, and best practices and discover techniques to successfully develop complex systems Key Features Discover how to manage increased complexity and understand systems better via effective communication Adopt a proven model-based approach for systems engineering in your organization Apply proven techniques for requirements, design, validation and verification, and systems engineering management Book Description Systems engineering

helps us to understand, specify, and develop complex systems, and is applied across a wide set of disciplines. As systems and their associated problems become increasingly complex in this evermore connected world, the need for more rigorous, demonstrable, and repeatable techniques also increases. Written by Professor Jon Holt – an internationally recognized systems engineering expert – this book provides a blend of technical and business aspects you need to understand in order to develop successful systems. You'll start with systems engineering basics and understand the complexity, communication, and different stakeholders' views of the system. The book then covers essential aspects of model-based systems engineering, systems, life cycles, and processes, along with techniques to develop systems. Moving on, you'll explore system models and visualization techniques, focusing on the SysML, and discover how solutions can be defined by developing effective system design, verification, and validation techniques. The book concludes by taking you through key management processes and systems engineering best practices and guidelines. By the end of this systems engineering book, you'll be able to confidently apply modern model-based systems engineering techniques to your own systems and projects. What you will learn

Understand the three evils of systems engineering - complexity, ambiguous communication, and lack of understanding

Realize successful systems using model-based systems engineering

Understand the concept of life cycles and how they control the evolution of a system

Explore processes and related concepts such as activities, stakeholders, and resources

Discover how needs fit into the systems life cycle and which processes are relevant and how to comply with them

Find out how design, verification, and validation fit into the life cycle and processes

Who this book is for This book is for aspiring systems engineers, engineering managers, or anyone looking to apply systems engineering practices to their systems and projects. While a well-structured, model-based approach to systems engineering is an essential skill for engineers of all disciplines, many companies are finding that new graduates have little understanding of systems engineering. This book helps you acquire this skill with the help of a simple and practical approach to developing successful systems. No prior knowledge of systems engineering or modeling is required to get started with this book.

MODELING AND VISUALIZATION OF COMPLEX SYSTEMS AND ENTERPRISES

EXPLORATIONS OF PHYSICAL, HUMAN, ECONOMIC, AND SOCIAL PHENOMENA

John Wiley & Sons Explains multi-level models of enterprise systems and covers modeling methodology This book addresses the essential phenomena underlying the overall behaviors of complex systems and enterprises. Understanding these phenomena can enable improving these systems. These phenomena range from physical, behavioral, and organizational, to economic and social, all of which involve significant human components. Specific phenomena of interest and how they are represented depend on the questions of interest and the relevant domains or contexts. Modeling and Visualization of Complex Systems and Enterprises examines visualization

of phenomena and how understanding the relationships among phenomena can provide the basis for understanding where deeper exploration is warranted. The author also reviews mathematical and computational models, defined very broadly across disciplines, which can enable deeper understanding. Presents a 10 step methodology for addressing questions associated with the design or operation of complex systems and enterprises Examines six archetypal enterprise problems including two from healthcare, two from urban systems, and one each from financial systems and defense systems Provides an introduction to the nature of complex systems, historical perspectives on complexity and complex adaptive systems, and the evolution of systems practice Modeling and Visualization of Complex Systems and Enterprises is written for graduate students studying systems science and engineering and professionals involved in systems science and engineering, those involved in complex systems such as healthcare delivery, urban systems, sustainable energy, financial systems, and national security.

UNIFYING THEMES IN COMPLEX SYSTEMS

VOLUME IIIB: NEW RESEARCH

Springer Science & Business Media *In recent years, scientists have applied the principles of complex systems science to increasingly diverse fields. The results have been nothing short of remarkable. The Third International Conference on Complex Systems attracted over 400 researchers from around the world. The conference aimed to encourage cross-fertilization between the many disciplines represented and to deepen our understanding of the properties common to all complex systems.*

ENGINEERING MEGA-SYSTEMS

THE CHALLENGE OF SYSTEMS ENGINEERING IN THE INFORMATION AGE

CRC Press *With their ability to cross traditional boundaries and achieve a level of functionality greater than their component elements, mega-systems have helped corporations and government organizations around the world resolve complex challenges that they otherwise couldn't address with stand-alone systems. Engineering Mega-Systems: The Challenge of Systems Engineering in the Information Age provides a clear understanding of the engineering of this class of systems—a process that demands consideration of increasing program scale and the rapid change of underlying technologies. Written by Renee Stevens, a Senior Principal Engineer at The MITRE Corporation with decades of experience analyzing, engineering, and acquiring large-scale systems for the U.S. Department of Defense and other government agencies, this book explains how the engineering of mega-systems is inherently different from that of large-scale monolithic systems. It supplies the vocabulary and framework needed to explore the issues relevant to mega-systems.*

This framework then evolves into the Profiler diagnostic tool that helps you understand the nature and context of the system at hand and, on that basis, select the most appropriate processes, tools, and techniques. Stevens examines commercial and government applications of mega-systems to provide insight into the contemporary challenges of engineering these systems in three critical dimensions: engineering processes, management processes, and the larger context in which these systems are developed and deployed. Complete with two case studies in engineering mega-systems that illustrate valuable lessons learned and highlight emerging practices, this book supplies the understanding and the tools needed to begin engineering, characterizing, and acquiring mega-systems across multiple dimensions.

SYSTEMS ENGINEERING

A SYSTEMIC AND SYSTEMATIC METHODOLOGY FOR SOLVING COMPLEX PROBLEMS

CRC Press *This book will change the way you think about problems. It focuses on creating solutions to all sorts of complex problems by taking a practical, problem-solving approach. It discusses not only what needs to be done, but it also provides guidance and examples of how to do it. The book applies systems thinking to systems engineering and introduces several innovative concepts such as direct and indirect stakeholders and the Nine-System Model, which provides the context for the activities performed in the project, along with a framework for successful stakeholder management. A list of the figures and tables in this book is available at <https://www.crcpress.com/9781138387935>. FEATURES • Treats systems engineering as a problem-solving methodology • Describes what tools systems engineers use and how they use them in each state of the system lifecycle • Discusses the perennial problem of poor requirements, defines the grammar and structure of a requirement, and provides a template for a good imperative construction statement and the requirements for writing requirements • Provides examples of bad and questionable requirements and explains the reasons why they are bad and questionable • Introduces new concepts such as direct and indirect stakeholders and the Shmemp! • Includes the Nine-System Model and other unique tools for systems engineering*

ADVANCES IN COMPLEX SOCIETAL, ENVIRONMENTAL AND ENGINEERED SYSTEMS

Springer *This book addresses recent technological progress that has led to an increased complexity in many natural and artificial systems. The resulting complexity research due to the emergence of new properties and spatio-temporal interactions among a large number of system elements - and between the system and its environment - is the primary focus of this text. This volume is divided into three parts: Part one focuses on societal and ecological systems, Part two deals with approaches for understanding, modeling, predicting and mastering socio-technical systems, and Part three includes real-life examples. Each chapter has its own special*

features; it is a self-contained contribution of distinguished experts working on different fields of science and technology relevant to the study of complex systems. *Advances in Complex Systems of Contemporary Reality: Societal, Environmental and Engineered Systems* will provide postgraduate students, researchers and managers with qualitative and quantitative methods for handling the many features of complex contemporary reality.

UNDERSTANDING COMPLEX ECOSYSTEM DYNAMICS

A SYSTEMS AND ENGINEERING PERSPECTIVE

Academic Press *Understanding Complex Ecosystem Dynamics: A Systems and Engineering Perspective* takes a fresh, interdisciplinary perspective on complex system dynamics, beginning with a discussion of relevant systems and engineering skills and practices, including an explanation of the systems approach and its major elements. From this perspective, the author formulates an ecosystem dynamics functionality-based framework to guide ecological investigations. Next, because complex system theory (across many subject matter areas) is crucial to the work of this book, relevant network theory, nonlinear dynamics theory, cellular automata theory, and roughness (fractal) theory is covered in some detail. This material serves as an important resource as the book proceeds. In the context of all of the foregoing discussion and investigation, a view of the characteristics of ecological network dynamics is constructed. This view, in turn, is the basis for the central hypothesis of the book, i.e., ecological networks are ever-changing networks with propagation dynamics that are punctuated, local-to-global, and perhaps most importantly fractal. To analyze and fully test this hypothesis, an innovative ecological network dynamics model is defined, designed, and developed. The modeling approach, which seeks to emulate features of real-world ecological networks, does not make a priori assumptions about ecological network dynamics, but rather lets the dynamics develop as the model simulation runs. Model analysis results corroborate the central hypothesis. Additional important insights and principles are suggested by the model analysis results and by the other supporting investigations of this book – and can serve as a basis for going-forward complex system dynamics research, not only for ecological systems but for complex systems in general. Provides a fresh interdisciplinary perspective, offers a broad integrated development, and contains many new ideas Clearly explains the elements of the systems approach and applies them throughout the book Takes on the challenging and open issues of complex system network dynamics Develops and utilizes a new, innovative ecosystem dynamics modeling approach Contains over 135 graphic illustrations to help the reader visualize and understand important concepts

DYNAMIC RELIABILITY ANALYSIS AND DESIGN FOR COMPLEX ENGINEERED SYSTEMS

Ensuring a high level of system reliability throughout a product life-cycle is one of paramount tasks for engineering design, which

requires new reliability analysis and design techniques to effectively address the challenges of system design under time-variant probabilistic constraints, such as those induced by time-dependent loading condition and system component deterioration. Extensive reviews on existing literature on reliability analysis and reliability based design optimization for complex engineered systems have identified important challenge problems to be addressed in this research, which have been organized into three research thrusts as follows: -Reliability Analysis using Surrogate Models: In this research thrust, the objective is to develop a robust approach to approximate static reliability efficiently and accurately based on surrogate models. Two challenge problems will be addressed: (1) How to evaluate fidelity of surrogate models and accuracy of reliability approximation based on those models, and (2) How to efficiently update a surrogate model if it does not meet the accuracy requirement. -Reliability Analysis with Time-variant Probabilistic Constraints. In this research thrust, the objective is to develop an efficient approach for dynamic reliability analysis considering time-variant probabilistic constraints. There are two challenges to be addressed: (1) How to handle the time-dependency of system failure events in dynamic reliability analysis, and (2) How to improve the efficiency of dynamic reliability analysis. -Reliability Analysis with Multiple System Failure Modes. The objective of this thrust is to develop a novel system reliability analysis framework to address a grand challenge in design that multiple system failure modes must be addressed concurrently to ensure a high level of system reliability.

CONTROL OF COMPLEX SYSTEMS

STRUCTURAL CONSTRAINTS AND UNCERTAINTY

Springer Science & Business Media "Control of Complex Systems: Structural Constraints and Uncertainty" focuses on control design under information structure constraints, with a particular emphasis on large-scale systems. The complexity of such systems poses serious computational challenges and severely restricts the types of feedback laws that can be used in practice. This book systematically addresses the main issues, and provides a number of applications that illustrate potential design methods, most which use Linear Matrix Inequalities (LMIs), which have become a popular design tool over the past two decades. Authors Aleksandar I. Zecevic and Dragoslav D. Siljak use their years of experience in the control field to also: Address the issues of large-scale systems as they relate to robust control and linear matrix inequalities Discuss a new approach to applying standard LMI techniques to large-scale systems, combining graphic-theoretic decomposition techniques with appropriate low-rank numerical approximations and dramatically reducing the computational effort Providing numerous examples and a wide variety of applications, ranging from electric power systems and nonlinear circuits to mechanical problems and dynamic Boolean networks "Control of Complex Systems: Structural Constraints and Uncertainty" will appeal to practicing engineers, researchers and students working in control design and other related

areas.

COMPLEX SYSTEMS DESIGN & MANAGEMENT

PROCEEDINGS OF THE NINTH INTERNATIONAL CONFERENCE ON COMPLEX SYSTEMS DESIGN & MANAGEMENT, CSD&M PARIS 2018

Springer *This book contains all refereed papers accepted during the ninth edition of the conference that took place at the Cité Internationale Universitaire de Paris on December 18-19, 2018. Mastering complex systems requires an integrated understanding of industrial practices as well as sophisticated theoretical techniques and tools. This explains the creation of an annual go-between forum in Paris dedicated to academic researchers & industrial actors working on complex industrial systems architecture, modeling & engineering. These proceedings cover the most recent trends in the emerging field of Complex Systems, both from an academic and a professional perspective. A special focus is put on “Products & services development in a digital world”. The CSD&M Paris 2018 conference is organized under the guidance of CESAM Community (<http://cesam.community/en>). CESAM Community has been developed since 2010 by the non-profit organization CESAMES Association to organize the sharing of good practices in Enterprise and Systems Architecture and to certify the level of knowledge and proficiency in this field through CESAM certification.*

SYSTEMS ENGINEERING

FUNDAMENTALS AND APPLICATIONS

Springer *This translation brings a landmark systems engineering (SE) book to English-speaking audiences for the first time since its original publication in 1972. For decades the SE concept championed by this book has helped engineers solve a wide variety of issues by emphasizing a top-down approach. Moving from the general to the specific, this SE concept has situated itself as uniquely appealing to both highly trained experts and anybody managing a complex project. Until now, this SE concept has only been available to German speakers. By shedding the overtly technical approach adopted by many other SE methods, this book can be used as a problem-solving guide in a great variety of disciplines, engineering and otherwise. By segmenting the book into separate parts that build upon each other, the SE concept’s accessibility is reinforced. The basic principles of SE, problem solving, and systems design are helpfully introduced in the first three parts. Once the fundamentals are presented, specific case studies are covered in the fourth part to display potential applications. Then part five offers further suggestions on how to effectively practice SE principles; for example, it not only points out frequent stumbling blocks, but also the specific points at which they may appear. In the final part, a wealth of*

different methods and tools, such as optimization techniques, are given to help maximize the potential use of this SE concept. Engineers and engineering students from all disciplines will find this book extremely helpful in solving complex problems. Because of its practicable lessons in problem-solving, any professional facing a complex project will also find much to learn from this volume.