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EDITED BY
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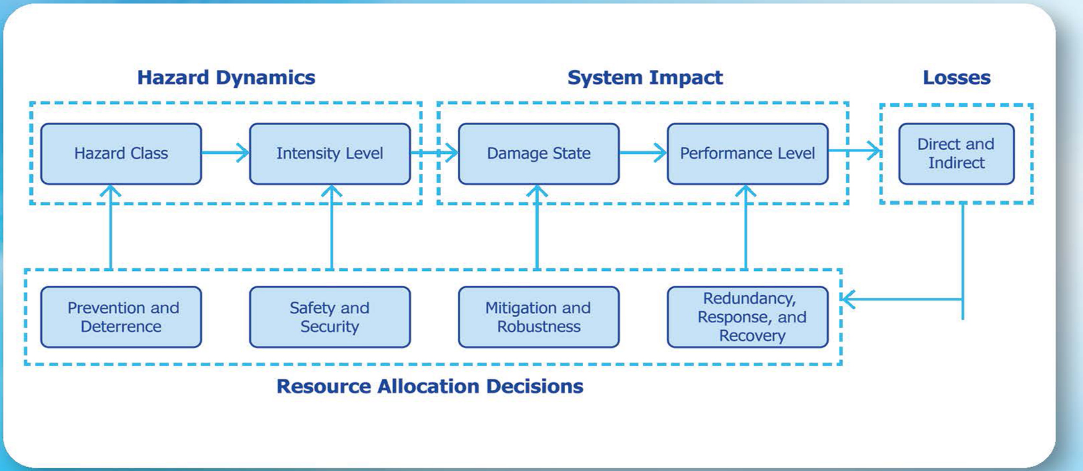
APPLIED RISK ANALYSIS FOR GUIDING HOMELAND SECURITY POLICY AND DECISIONS



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Samrat dedicates this book to his dearest Arianna, Aariv, Zyra, and Zara – stay curious, keep learning!

Robert dedicates this book to his lovely granddaughters Amelia Rose and Emmalyn Mae – blessings always!

Angela dedicates this book to Andy, Scarlett, and Archer

Contents

About the Editors

Dr. Samrat Chatterjee is a Senior Data/Operations Research Scientist and the Decision Modeling and Optimization Team Lead with the National Security Directorate at the Pacific Northwest National Laboratory (PNNL). His research focuses on assessing and managing risks to critical cyber and physical infrastructure systems and processes from multiple hazards using interdisciplinary modeling, simulation, data analytics, and operations research methods. His research activities at PNNL focus on national security in support of the Department of Homeland Security, Department of Energy, and the Department of Defense. He recently co-authored a Springer book on economic consequence analysis of disasters and has published over 65 peer-reviewed journal articles, conference papers, and technical reports, including two best paper awards in cybersecurity and disaster resilience at an Institute of Electrical and Electronics Engineers (IEEE) homeland security conference. He is current chair of the Security and Defense specialty group, and past chair of the Engineering and Infrastructure specialty group of the Society for Risk Analysis (SRA), and recently completed a membership term with the National Academies' Transportation Research Board's (TRB) Committee on Transportation of Hazardous Materials. His experience includes disaster risk modeling at the International Institute for Applied Systems Analysis (IIASA) in Austria on a National Academy of Sciences (NAS) fellowship through a National Science Foundation (NSF) grant and traffic flow simulation for an engineering consulting firm. Samrat conducted postdoctoral research on infrastructure risk and decision analysis at the US Homeland Security National Center of Excellence for Risk and Economic Analysis of Terrorism Events (DHS-CREATE) at the University of Southern California. Dr. Chatterjee holds a PhD in Civil Engineering with focus on systems risk analysis from Vanderbilt University, an MS in Civil Engineering with focus on transportation systems from the University of Texas at Austin, and a BE with honors in Civil Engineering from Punjab Engineering College, India. Samrat also serves as an Affiliate Professor of Civil and Environmental Engineering with Northeastern

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Dr. Robert T. Brigantic is a Chief Operations Research Scientist and the Statistical Modeling and Experimental Design Team Lead with the National Security Directorate at the Pacific Northwest National Laboratory (PNNL). He is a US Air Force officer who joined PNNL in 2005 after completing a 22-year career on active duty with the US Air Force. In the Air Force he specialized in weapon systems logistics, space operations with a focus on command and control systems for space shuttle operations and space test systems, and strategic airlift transportation. His technical concentration areas include operational modeling and simulation, systems analysis, statistical pattern recognition/artificial intelligence, imagery analysis, design of experiments, and multiobjective optimization. At PNNL, some of his research initiatives include operationalizing methodologies for national security risk analysis, modeling and simulation of operational radiation/nuclear detection processes, systems analysis, and optimization of renewable energy systems and energy efficiency measures. Dr. Brigantic holds a PhD in Operations Research from the Air Force Institute of Technology, an MS in Space Operations from the Air Force Institute of Technology, and a BS in Chemical Engineering from Oregon State University. He also serves as an Adjunct Professor of Operations Research with Washington State University.

Ms. Angela M. Waterworth is a Senior Research Scientist with the National Security Directorate at the Pacific Northwest National Laboratory (PNNL) and currently serves as the Technical Advisor for Data Science for Defense Nuclear Nonproliferation Research and Development at the National Nuclear Security Administration. Ms. Waterworth joined PNNL after a distinguished career as an Operations Research Analyst in the US Air Force, where she specialized in research and development and technical intelligence of weapon systems. At PNNL, Ms. Waterworth has led project teams to develop operational modeling and decision support methodologies to analyze and reduce system risk, forecast cost and performance, and optimize resource allocation related to real-world national security systems for threats including nuclear proliferation and smuggling and emergency response to biological weapons. Additionally, Ms. Waterworth leads multidisciplinary efforts in the research and development of US technical capabilities to detect nuclear weapons development, with special focus on incorporating modern analytics approaches and computing technologies. Ms. Waterworth holds an MS in Operations Research from Kansas State University and a BS in Economics from the US Air Force Academy.

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Preface

The US Department of Homeland Security's (DHS) risk landscape spans across multiple intentional, accidental, and natural threats and hazards. These threats and hazards may be directed at and affect various critical national assets, systems, and processes and potentially lead to significant adverse human, societal, economic, and governance impacts. As a result, effective assessment and management of risks to the nation's security from such threats and hazards is both vital and challenging. As described in the 2014 Quadrennial Homeland Security Review (Department of Homeland Security (2014) *The 2014 Quadrennial Homeland Security Review*), DHS's five missions are to: (i) prevent terrorism and enhance security, (ii) secure and manage our borders, (iii) enforce and administer our immigration laws, (iv) safeguard and secure cyberspace, and (v) strengthen national preparedness and resilience. Analysis and comparison of risks from various threats and hazards is critical for accomplishing these missions. Also, as these threats and hazards evolve over time and critical systems become more connected and complex, risk assessment and management strategies need to adequately update as well while incorporating data and computing advances with subject matter expertise.

Risk analysis methods may be qualitative, semiquantitative, or quantitative, adopt probabilistic and statistical theories, and implement concepts from core disciplines including operations research, reliability engineering, systems engineering, and applied mathematics. These methods continue to develop and evolve and have successfully been applied to address various homeland security mission challenges in recent years. The objective of this edited volume is to: (i) highlight the role of risk science for informing homeland security policy decisions and (ii) describe case studies from academia, government, and industry that apply risk analysis methods for addressing challenges within DHS mission spaces. This volume is intended for homeland security policy analysts and practitioners interested in applications of security risk analysis methods. The content presented here might also be useful for researchers and students interested in state-of-the-art homeland security risk analysis research and development.

This edited volume owes a debt of gratitude to 49 contributors from institutions across academia, national laboratories, and industry. The three editors were fortunate to receive an outstanding collection of contributions from leading researchers on a myriad of topics within the homeland security risk and decision analysis space. The editors also thank the management within the National Security Directorate at Pacific Northwest National Laboratory for encouraging and supporting the development of this volume. This edited volume is organized into 4 thematic parts/sections with 19 total chapters based on DHS's missions: (i) "Managing National Security Risk and Policy Programs," (ii) "Strengthening Ports of Entry," (iii) "Securing Critical Cyber Assets," and (iv) "Enhancing Disaster Preparedness and Infrastructure Resilience."

Part I contains five chapters: Chapter 1 "On the 'Influence of Scenarios to Priorities' in Risk and Security Programs" by Thorisson and Lambert from the University of Virginia, Chapter 2 "Survey of Risk Analytic Guidelines Across the Government" by Maya et al. from the University of Southern California, Chapter 3 "An Overview of Risk Modeling Methods and Approaches for National Security" by Chatterjee et al. from the Pacific Northwest National Laboratory, Chapter 4 "Comparative Risk Rankings in Support of Homeland Security Strategic Plans" by Lundberg from Sam Houston State University, and Chapter 5 "A Data Science Workflow for Discovering Spatial Patterns Among Terrorist Attacks and Infrastructure" by Fortin et al. from the Pacific Northwest National Laboratory.

Part II contains three chapters: Chapter 6 "Effects of Credibility of Retaliation Threats in Deterring Smuggling of Nuclear Weapons" by Shan and Zhuang from the State University of New York at Buffalo, Chapter 7 "Disutility of Mass Relocation After a Severe Nuclear Accident" by Bier and Liu from the University of Wisconsin–Madison, and Chapter 8 "Scheduling Federal Air Marshals Under Uncertainty" by DeGregory and Ganesan from US Military Academy and George Mason University, respectively.

Part III contains three chapters: Chapter 9 "Decision Theory for Network Security: Active Sensing for Detection and Prevention of Data Exfiltration" by McCarthy et al. from the University of Southern California and Hewlett Packard Labs, Chapter 10 "Measurement of Cyber Resilience from an Economic Perspective" by Rose and Miller from the University of Southern California, and Chapter 11 "Responses to Cyber Near-Misses: A Scale to Measure Individual Differences" by Cui et al. from the University of Southern California.

Part IV contains eight chapters: Chapter 12 "An Interactive Web-Based Decision Support System for Mass Dispensing, Emergency Preparedness, and Biosurveillance" by Lee et al. from Georgia Institute of Technology and Centers for Disease Control and Prevention, Chapter 13 "Measuring Critical Infrastructure Risk, Protection, and Resilience in an All-Hazards Environment" by Phillips and Petit from the Perduco Group and Argonne National Laboratory, respectively, Chapter 14 "Risk Analysis Methods in Resilience

Modeling: An Overview of Critical Infrastructure Applications" by Baroud from Vanderbilt University, Chapter 15 "Optimal Resource Allocation Model to Prevent, Prepare, and Respond to Multiple Disruptions, with Application to the Deepwater Horizon Oil Spill and Hurricane Katrina" by MacKenzie and Al-Kazimi from the Iowa State University, Chapter 16 "Inoperability Input–Output Modeling of Electric Power Disruptions" by Santos et al. from George Washington University and University of Massachusetts–Lowell, Chapter 17 "Quantitative Assessment of Transportation Network Vulnerability with Dynamic Traffic Simulation Methods" by Shekar and Fiondella from the University of Massachusetts–Dartmouth, Chapter 18 "Infrastructure Monitoring for Health and Security" by Basu from Vanderbilt University, and Chapter 19 "Exploring Metaheuristic Approaches for Solving the Traveling Salesman Problem Applied to Emergency Planning and Response" by Tipireddy et al. from the Pacific Northwest National Laboratory and St. Mary's University.

Richland, WA, USA
26 November 2018

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Chapter Abstracts

Chapter 1 – Page 3 (Thorisson and Lambert)

On the "Influence of Scenarios to Priorities" in Risk and Security Programs

Organizations increasingly follow comprehensive guidelines and standards when implementing programs for the assessment and management of risk, safety, resilience, or security. Programs often involve the coordination of multiple systems, of stakeholders and organizational units, and require balancing different needs and missions, as well as being flexible and having the ability to withstand and adjust to emerging conditions of economics, policies, military conflict, environment, and other factors. This chapter suggests three canonical questions as the mission of such a program: (i) what sources of risks are to be managed by the program; (ii) how should multiple risk assessment, risk management, and risk communication activities be administered and coordinated, and what should be the basis for resource allocation to these activities; and (iii) how will the performance of the program be monitored and evaluated. An approach to evaluate how different components of a program comply with guidelines and how various risk scenarios influence the priorities of the program is demonstrated. Thus, it emphasizes the preparedness of programs whose priorities adjust to emergent conditions of technology, environment, demographics, markets, regulations, organizations, and geography. The methods presented are useful to organizations and agencies implementing risk guidelines for security, infrastructure, finance, logistics, emergency management, resilience, and preparedness.

Chapter 2 – Page 25 (Maya, Liu, Zhu, Tran, Creighton and Woo)

Survey of Risk Analytic Guidelines Across the Government

The Department of Homeland Security (DHS) has been developing its guidance for standardizing risk analyses practices to facilitate high quality, data fidelity, utility of results, and appropriate consistency for the analyses performed by