

# Preface

## Motivation

We live in the information age and every technology in today's modern world is based on information technology. Scientific theories—introduced in the last five decades—are realized with today's scalable computational infrastructure effectively characterized by Moore's Law. Modeling and Simulation (M&S), along with Big Data technologies, is at the forefront of such exploration and investigation. Furthermore, simulation has a unique characteristic: Dynamic models associated with diverse experimental conditions and scenarios (sometimes in extreme and even at adverse conditions) have the power of generating new knowledge.

M&S is often taken as a single activity but in practice and engineering, are separate activities. While modeling has been adequately embraced by various disciplines, leading to many modeling techniques, many times the modeling activity is not supported by simulation activity. On the other hand, a simulation-based approach subsumes modeling as an inherent activity. As editors, we believe while modeling helps in bringing a common understanding across all stakeholders (e.g., scientists, engineers, practitioners), it is usually through simulation that a model's correctness is evaluated. A validated model must be amenable to simulation. A *model* represents a real-world phenomenon using abstractions. A properly validated and verified and properly computerized model lends itself to experimentation. Experimentation with a dynamic model as well as gaining experience based on a dynamic model lies within the domain of simulation-based approaches.

This book has several examples from diverse disciplines demonstrating simulation maturity to provide a solid basis for advancement in many disciplines; from life sciences to engineering; from architecture to arts to social sciences. As a sign of the times, we are truly at the crossroads where M&S is becoming a “discipline”. This book emphasizes the fact that simulation may enhance the power of many disciplines. Not only is M&S benefiting disciplines like sociology, which has largely been insulated from such experimentation, but it is also undoubtedly used in

every aspect of life, whether transportation, finance, economics, biology, and so forth.

The book's emphasis is on highlighting the state-of-the-art simulation in the modern era and how simulation-based approaches across multiple disciplines advance the very discipline itself.

## Overview

The book is organized in Background, Engineering and Architecture, Natural Sciences, Social Sciences and Management, and Learning, Education and Training sections. We appreciate very much our eminent colleagues who accepted our invitations to contribute to this volume.

The Background section endeavors to provide a comprehensive simulation view in two chapters. In Chap. 1, the editors, Tuncer Ören, Saurabh Mittal and Umut Durak, try to establish a base for the book by elaborating simulation evolution and highlighting simulation as vital infrastructure for many disciplines. Ernest H. Page presents in Chap. 2 the simulation technology landscape in academia, industrial and government sectors throughout various scientific and engineering disciplines.

The Engineering and Architecture section is composed of six chapters each drawing attention to a certain technical domain. In Chap. 3, Melih Çakmakcı, Güllü Kızıldaş Şendur, and Umut Durak address the role of simulation in engineering design. Andreas Tolk, Christopher G. Glazner, and Robert Pitsko promote simulation in Chap. 4 as an evolution of model-based systems engineering toward an integrated discipline within systems engineering. Chapter 5 Simulation-Based Cyber-Physical Systems and Internet of Things by Bo Hu Li, Lin Zhang, Tan Li, Ting Yu Lin, and Jin Cui explains the relation of simulation with these emerging fields of technical systems. In Chap. 6, Saurabh Mittal and Jose Luis Risco Martin accentuate complex and adaptive systems and introduce required simulation infrastructure for their design. Following that, Chap. 7 is from Oryal Tanir, where he presents simulation as a means of understanding the impact of a new complex solution on the business and information technology process in a software design life cycle. The last chapter of this section is by Rhys Goldstein and Azam Khan. They introduce the emerging role of simulation in designing model compelling, functional, sustainable, and cost-effective buildings in Chap. 8.

The Natural Sciences section includes two chapters. First in Chap. 9, Levent Yilmaz conducts a comprehensive discussion on the position of simulation in relation to scientific method towards simulation-based science. Then in Chap. 10 Hannes Prescher, Allan H. Hamilton, and Jerzy Rozenblit introduce the contribution of simulation to health-care as well as health education and training.

The Social Sciences and Management section contains two chapters. It starts with Chap. 11 where David C. Earnest and Erika Frydenlund introduce simulation evolution in social sciences and discuss its position in research. In Chap. 12 Greg Zacharewicz, Amir Pirayesh-Neghab, Marco Seregni, Yves Ducq, and Guy

Doumeingts present simulation of service systems for simulation-based enterprise management.

The last two chapters establish the Learning, Education and Training section. In Chap. 13, Tuncer Ören, Charles Turnitsa, Saurabh Mittal and Saikou Diallo present the role of simulation in learning and education. Finally, the last chapter by Agostino Bruzzone and Marina Massei discusses the role of simulation in military training.

## Invitation

The notable contribution of this book is providing a comprehensive collection of chapters from diverse disciplines with the unique characteristics of simulation. Authors explore and elaborate the position of simulation within their domain and note its impact for the advancements of their disciplines. We invite you to a journey about simulation through various disciplines and anticipate that such a synergistic approach will provide you an overview of the role of simulation as we are advancing towards a computational future in the twenty-first century: a computational future to be enhanced and empowered by simulation-based approaches.

Herndon, VA, USA  
Braunschweig, Germany  
Ottawa, ON, Canada  
February 2017

Saurabh Mittal<sup>1</sup>  
Umut Durak  
Tuncer Ören

---

<sup>1</sup>The authors affiliation with The MITRE Corporation is provided for identification purposes only, and is not intended to convey or imply MITRE's concurrence with, or support for, the positions, opinions or viewpoints expressed by the author. Approved for public release: Case: 17-0904.

Guide to Simulation-Based Disciplines

Advancing Our Computational Future

Mittal, S.; Durak, U.; Oren, T. (Eds.)

2017, XIX, 370 p. 86 illus., 57 illus. in color., Hardcover

ISBN: 978-3-319-61263-8