Stephen Adams · Peter A. Beling
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Cody H. Fleming *Editors*

Systems Engineering in Context

Proceedings of the 16th Annual Conference on Systems Engineering Research

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Preface

The papers that comprise this volume were presented at the 16th Annual Conference on Systems Engineering Research (CSER 2018). The conference was held on May 8–9, 2018, at the University of Virginia (UVA) in Charlottesville, Virginia, USA. The co-chairs of the conference were Peter A. Beling (UVA) and William T. Scherer (UVA). The honorary chair of the conference was Yacov Y. Haimes (UVA). The program chair was Stephen Adams (UVA), and the panel chair was Cody Fleming (UVA). The publication chairs were James H. Lambert (UVA) and Brian Park (UVA).

The CSER 2018 Program Committee had participation of a wide range of universities and companies, including Carl Elks (Virginia Commonwealth University), Cody Fleming (UVA), Yacov Y. Haimes (UVA), James H. Lambert (UVA), Brian Park (UVA), Michael Farnsworth (UVA), David Long (Vitech Corp.), Tom McDermott (Georgia Tech), Chris Paredis (Clemson University), Alejandro Salado (Virginia Tech), Lu Xiao (Stevens Institute of Technology), Ye Yang (Stevens Institute of Technology), Steve Y. Yang (Stevens Institute of Technology), Roger Georges Ghanem (University of Southern California), and N. Peter Whitehead (The MITRE Corporation).

The 2018 theme "Systems in Context" is inclusive of topics across systems engineering, industrial engineering, systems acquisition, engineering management, operations research, engineering systems, and related fields. Few systems operate independently of other systems and stakeholders. Understanding the interactions with other entities and the context in which a system will be used is paramount to the design process. The conference featured papers from a wide range of domains and topics including:

- Systems in context and applications of systems engineering concepts
- Theoretical foundations of systems engineering
- Systems-of-systems design
- Integration of systems
- Complex and large-scale systems

- Human factors, human-machine interaction, and cyber-human systems
- Simulation integration into systems engineering
- Optimization and multi-criteria decision-making
- Risk and resilience
- Distributed decision-making and control
- Model-based systems, stochastic modeling, and state estimation
- Data-driven decision-making in large-scale systems
- Data collection, storing, and handling for large-scale systems
- Sensor and data fusion in large-scale systems
- Autonomous systems
- Safety and security systems
- Transportation systems
- Cyber-physical systems and the Internet of Things

We would like to thank all of the authors and presenters for participating in CSER 2018 and contributing to a positive learning experience in Charlottesville. We would also like to thank all that contributed to organizing the conference.

Charlottesville, VA, USA
May 2018

Stephen Adams
Peter A. Beling
James H. Lambert
William T. Scherer
Cody H. Fleming

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About the Editors

Stephen Adams PhD is a senior research scientist in the Systems and Information Engineering Department at the University of Virginia. His research interests include feature selection, machine learning with cost, sequential decision-making, reinforcement learning, and probabilistic modeling of systems. He is currently part of the Adaptive Decision Systems Lab at UVA, and his research is applied to several domains including activity recognition, prognostics and health management for manufacturing systems, psychology, cybersecurity, data trustworthiness, natural language processing, and predictive modeling of destination given user geo-information data.

Peter A. Beling is a professor in the Engineering Systems and Environment (ESE) Department at the University of Virginia (UVA). Dr. Beling's research interests are in the area of decision-making in complex systems, with emphasis on artificial intelligence systems and on model-based approaches to system-of-systems design and assessment. His research has found application in a variety of domains, including mission-focused cybersecurity, reconnaissance and surveillance, prognostic and diagnostic systems, and financial decision-making. He directs the UVA site of the Center for Visual and Decision Informatics, a National Science Foundation Industry/University Cooperative Research Center, and the Adaptive Decision Systems Laboratory, which focuses on data analytics and decision support in cyber-physical systems. He is a member of UVA's Data Science Institute and its Link Lab for Cyber-Physical Systems. Dr. Beling has served in numerous editorial roles and has been a member of five National Academies panels. Dr. Beling received his Ph.D. in operations research from the University of California at Berkeley.

James H. Lambert FIEEE, FASCE, FSRA, DWRE, PE, MINCOSE, MAAAS is a professor of systems and information engineering at the University of Virginia, USA. He is the chair of the SRA Fifth World Congress on Risk in Cape Town, South Africa, in 2019. He is a past president (2015–2016) of the Society for Risk Analysis and a past chair (2015) of the SRA Annual Meeting. He is a founding editor-in-chief of the Springer journal *Environment Systems and Decisions* and area editor of the Wiley journal *Risk Analysis* and serves on the Editorial Board of the ASCE/ASME *Journal of Risk and Uncertainty in Engineering Systems*. He is a founding co-chair of the IEEE Technical Committee on Social and Economic Security. He has PhD and MS from the University of Virginia (1994, 1990) and BSE (1988) from Princeton University. He serves on the Technical Advisory Committee of the Commonwealth Center for Advanced Logistics Systems.

William T. Scherer SEBS, ME, PhD is an expert in systems engineering and stochastic control. Professor Scherer has served on the University of Virginia Department of Systems and Information Engineering Faculty since 1986. He has authored and co-authored numerous publications on intelligent decision support systems, combinatorial optimization, and stochastic control. His current research focuses on systems engineering methodology, financial engineering, and intelligent transportation systems. His co-authored book, *How To Do Systems Analysis*, was published by Wiley in 2007, and his follow-on book, *How To Do Systems Analysis: Primer and Casebook*, was also published by Wiley in 2016. He was also a visiting professor at the Darden Graduate School of Business in 2001–2002 and the president of the IEEE Intelligent Transportation Systems (ITS) Society 2007–2008.

Cody H. Fleming is an assistant professor of systems engineering and aerospace engineering at the University of Virginia. He received his PhD in aeronautics and astronautics at the Massachusetts Institute of Technology. Broadly, Dr. Fleming is interested in system modeling and analysis during all phases of development of complex systems, particularly those with high levels of automation. He has investigated several next-generation air traffic management initiatives during the early concept formation stages as well as safety assurance and algorithm development for driverless and connected vehicles. Related research interests lie in modern feedback control, dynamics, and modeling as well as model-based systems engineering and system assurance. In addition, Cody worked for several years in the aerospace industry, developing large satellite systems and laser systems in all phases of systems engineering including design, analysis, testing, integration, and validation and verification.

Chapter 1
Toward Achieving Architecture Alignment of Business and IT: A Portfolio Decision Analysis Approach

Mengmeng Zhang, Honghui Chen, and Kalle Lyytinen

1.1 Introduction

The fit between the business domain and IT domain of a firm contributes to "maximizing the return value of IT investments," [1, 2] "helping to improve IT usage," [3, 4] and "improving overall company performance" [5, 6]. However, there are currently different ways of aligning the business domain and IT domain; for example, strategic alignment [7–9], architecture alignment [10, 11], and business alignment [12, 13] are some of the many types of alignment problems discussed and investigated in the literature. While most research and practice have focused on strategic alignment to synchronize IT and business plans, our research suggests that architecture alignment is equally important. Architecture alignment brings strategic alignment to the practical level and creates value from architecture design and management.

Several alignment dimensions, such as social [14, 15], cultural [14, 16], and structural [17, 18], were often considered in the various types of alignment problems. This study focuses on the structural dimension of architecture alignment without regard for the other dimensions. In this paper, architecture alignment will refer to a structural fit between business elements (e.g., business processes, activities, and business structures) in business architecture and IT elements (e.g., applications, services, and software components) in IT architecture.

Two research questions (RQ) will be addressed in this paper:

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