In recent years, socio-technical systems have become more emphasized in systems-oriented research, as systems engineers seek to understand better how the technical systems that they design behave and perform in different socio-economic contexts, and as social scientists increase their use of engineering modeling and analysis methods such as simulation. Example socio-technical systems include healthcare delivery, multi-jurisdictional urban governance, and multi-tiered supply chains, among others. These systems features technical behavior and performance combined with behavioral impacts from people and organizations.

Socio-technical systems encompass many different phenomena, ranging from purely technical performance of man-made systems such as the power grid or communications networks, to natural phenomena such as weather and wildlife, to socio-economic and cultural behavior of individuals and societies. These elements interact with one another in complex, sometimes surprising ways. In large part, this is due to such systems’ having independent actors that can learn and evolve over time. Thus, adaptive behavior is a key feature.

From a systems modeling point of view, socio-technical systems present many different phenomena and data sources. Such systems often are conceptualized as systems-of-systems or networked systems. Modeling such systems can be problematic due to the heterogeneity of the phenomena and the corresponding different formalisms used to model them by different disciplines, creating problems in model composition and optimization of multiple objectives. In addition, the variety of data sources typically gives rise to a rich set of problems in data fusion. Data varies across geography, time scales and socio-economic or organizational level.

The papers in this section present a rich set of the concepts involved in socio-technical systems. In “Location Intelligence in Digital Data Activity Dimensioning in Smart Cities,” Jensen et al. address the concept of location intelligence as a means to convert the high volumes of heterogeneous data available in smart cities to forms amenable to decision-making. Smart cities are a significant application area for socio-technical systems design, modeling and analysis. People both create and consume data. In addition, the systems with which they interact create vast amounts of data. These data vary over geographic areas and time-scales. Jensen et al. create a location intelligence framework, methods and tools to map entity and service data to points to spatio-temporal points on a
geographical information system for a city and surrounding area. This allows data to be visualized to identify patterns and relationships for decision-making. They demonstrate the concept on a smart city case study incorporating housing, critical infrastructure, mobile services and crowd-sourcing.

Socio-technical factors are also being considered in defense-oriented systems. Bodner studies the socio-technical nature of the problem of counterfeit parts in defense systems in “Enterprise Modeling Framework for Counterfeit Parts in Defense Systems.” Increasingly, counterfeit parts are infiltrating defense systems as replacement parts through the networked supply chain. A variety of factors contribute to counterfeiting, including long systems lifespans and obsolescence, economic and cost considerations, and the difficulty in testing and detection. An enterprise framework is defined for the various interacting agencies and suppliers involved in defense sustainment. An associated agent-based model is created to study the effectiveness of various anti-counterfeiting policies in remediating the problem, keeping in mind that there are typically secondary effects of policies in socio-technical systems due to actor adaptation.

On the warfare side of defense systems, Young and Green address socio-technical aspects of deployed systems in “Achieving a Decision Paradigm for Distributed Warfare Resource Management.” Increasingly, sensor networks are used to monitor resources and threats. Information collected from the socio-technical battlefield must be presented in manner suitable for decision-making with respect to managing weapons and platforms. This involves a substantial effort in data fusion. Young and Green specify a resource management framework for doing so, one that incorporates decision engines for an overall measure of effectiveness based on constituent measures of effectiveness, for cost effectiveness assessment, and for decision confidence based on risk. The goal is to use this framework to support design and engineering of warfare resource systems-of-systems.

Energy is increasingly viewed as a socio-technical system, since both the technical aspects of the production and delivery system must be considered with the socio-economic behavior of consumers and markets. In the first of three energy-related papers, Zoolfakar et al. study the interaction of different components on the design of liquefied natural gas (LNG) carrier systems in “Holistic Study of Liquefied Natural Gas Carrier Systems.” These systems are used to deliver LNG overseas. The first set of components address the technical performance of such systems and include the carrier containment systems, the hull geometry, liquefaction plant systems, propellant power required, and propulsion machinery systems. The final component considered is the mission profile, which relates expected requirements for customer deliveries of LNG. Zoolfakar et al. then develop a framework for lifecycle cost analysis of these systems based on the interaction of these components.

The smart grid is another emerging application area for socio-technical systems. Cost and reliability are two key metrics in operating and expanding the transmission networks for the smart grid. Traditional optimization approaches, as well as more recent meta-heuristic methods, have been used to minimize cost for network expansion, but are limited in solving the multi-objective problem that also considers reliability. Hiroki and Mori develop a meta-heuristic that uses Pareto-optimality for the multi-objective nature of the problem in “An Efficient Multi-objective Metaheuristic Method for Probabilistic Transmission Network Expansion Planning.” Probabilistic effects are considered using Monte Carlo simulation to yield robust solutions. A simulation of a 24 node IEEE reliability set demonstrates a more flexible approach to network expansion that considers the trade-off between cost and reliability.

Finally, Mbodji et al. investigate a decentralized approach to optimizing the management of electricity generation using multiple sources of power in “Operation Optimal Dynamics of a Hybrid Electrical System: Multi-Agent Approach.” Consumers and producers are modeled as agents, with the dual goals of minimizing the production cost and minimizing the deviation of supply and demand. Producers utilize a variety of energy types, including renewables, and these often are characterized by intermittent production. Other agents serve as intermediaries between producers and consumers to facilitate transactions and cooperation. A variety of technical factors come into play due to the topology of the network and the intermittent production nature of many renewables, requiring storage capacity. A simulation model demonstrates an energy cost savings due to producer behavior and demand flexibility when a cost control strategy is used.