The twentieth and twenty-first centuries have been characterized as tumultuous (Martin 2006; Tainter 1988). This characterization fits within the scope of concepts of ambiguity, complexity, emergence, independency, and uncertainty (Keating et al. 2014; Katina 2015). Ambiguity is associated with an increasing lack of clarity and situational understanding while complexity is associated with large numbers of richly and dynamically interacting systems and subsystems with behavior difficult to predict. The concept of emergence is associated with inability to deduce behavior, structure, or performance from constituent elements while interdependency relates to mutual influence among different complex systems through which the state of a system influences, and is influenced by, the state of other interconnected systems. The uncertainty aspect of current landscape is associated with having incomplete knowledge casting doubt for decision/action consequences. Certainly, these concepts align with the notions of ‘messes’ (Ackoff 1974) and ‘wicked problems’ (Rittel and Webber 1973).

Operating under these conditions is a set of systems “so vital and ubiquitous that their incapacity or destruction would not only affect the security and social welfare of any nation, but also cascade across borders” (Gheorghe et al. 2007, p. 6). Examples of such system include but not limited to chemical industries, communication systems, emergency services, energy, food and agriculture, healthcare and public health, and transportation systems. Collectively, referred to as critical infrastructures, research pertaining to such systems tends to “addresses elements of assessment, remediation, indications and warnings, mitigation, response, and reconstruction pertaining to hazards, risks, and threats from natural and man-made events affecting public well-being—public safety, economic vitality, and security” (Gheorghe and Katina 2014, p. 194).

The importance of critical infrastructures can be highlighted on two fronts: first is the perspective of the level to which critical infrastructures influence public well-being. Arguably, all daily activities are influenced by goods and services that are provided by critical infrastructures: clean water, save food, lighting, banking, shopping, transportation...the list goes on. Continuous operability and availability
of critical infrastructure is imperative. Second is the consideration of frequency of occurrence and increasing loss of lives and property associated with natural and man-made events. Harmful events, natural or man-made, have always occurred. However, there has been unprecedented increase in occurrence and causalities associated with events such as hurricanes and terror attacks. These two fronts suggest a need for development of methodologies, methods, tools, and techniques capable of addressing emerging issues. This is not a new insight. In fact, it is widely accepted that science, state, business, and military have failed to deliver on their promises of a modern society free of risk (Beck 2006; Escobar 2004). In the context of critical infrastructures, addressing these issues might require thinking ‘outside and above’ the box.

These thoughts go hand-in-hand a quote that is often attributed to Albert Einstein, “We cannot solve our problems with the same level of thinking that created them.” The same sentiments are echoed by Hammond (2002) who suggests that “problems confronting humanity at this stage in our history (poverty, violence, crime, environmental degradation and nuclear weapons…terrorism) are systemic and cannot be understood or resolved in isolation” (p. 430). When these ideas are coupled with “dwindling applicability of ‘old’ methods and tools…[the] need to (re)think such issues as infrastructure protection, deterioration, assessment, remediation, indications and warnings, mitigation, response, and reconstruction” (Gheorghe and Katina 2014, p. 195) becomes apparent.

Therein these sentiments lay the purpose for the present research—the development of a sound framework for an innovative statistical approach to risk and vulnerability assessment in the transportation of hazardous materials (i.e., hazmat). To fulfill this purpose, eight chapters and four appendixes have been carefully crafted to enable understanding of concepts, ample utility of models, and transferability of the presented research. The intended audience of the book is primarily practitioners and analysts involved in managing risk associated with transportation of hazmat. However, business leaders and policy-makers will find this book useful especially since they are ultimately responsible for decisions involving business transactions including investment and development of policy that affect public well-being. Graduate students interested in the present topic may need to ‘pay a close attention’ to procedures involved in the development of equations and models.

Chapter 1 introduces the research domain of critical infrastructures along with the underlying themes from which the need for robust methodologies, methods, tools, and techniques has sprung. The need for new approaches is made more apparent in Chap. 2 with a consideration of risk and vulnerability associated with the transportation of hazmat. Specifically, a new and novel approach, hotspot, is introduced along with the underpinnings of spatial information and complementary cumulative distribution function.

Chapter 3 covers methods and corresponding equations related to probability of occurrence of loss of containment that result in accidents. This chapter includes detailed accounts on how to identify initiating events in the case of two modes of transportation: rail and road. Chapter 4 addresses consequences associated with loss
of containment. Types of consequences are discussed (fire, explosion, and acute intoxication) along with specific methods for their calculations.

An important aspect of risk is the conceptualization of vulnerability. How though do we define vulnerability? And more specifically, how can it be quantified for use in a methodology? Chapter 5 addressed this issue in general and then in the transportation system. Chapter 6 covers two methods that can be used in quantitative assessment of vulnerability in transportation systems. First is the Index Method which targets the assessment of the vulnerability level and second is the Matrix Method which, as the outcome, derives a robustness index. This chapter concludes with a proposed model for assessing vulnerability of transportation corridors.

Chapter 7 is a continuation of the models introduced in Chap. 6. It covers a quantitative vulnerability assessment method which models phenomena in multi-component systems. The first part of this chapter provides foundational information while the second part provides procedures for application of the method. The concluding chapter, Chap. 8, is a case application of present research. A real-world case scenario, a transportation system ‘Aarau-Zurich’ is selected and analyzed for hotspots.

There are four complementary appendixes; each provide essential information related to theory, methods, and utility of present research. Appendix A elaborates on methods and tools for Probabilistic Risk Assessment and Reliability, Availability, Maintainability and Safety from which master logical diagrams, event tree analysis, and life data analysis (important tools in present research) are derived. Appendix B introduces the importance of decision support systems in transportation of hazmat as well as elaborating on the utility geographical information system in spatial analysis. Appendix C provides guidelines for developing an integrated software platform for risk and vulnerability assessment in transportation of hazmat. A description of a proposed architecture and its constituent blocks is provided along with potential capabilities. Lastly, Appendix D is designed to offer defensible yet simplistic explanation of how one arrives at the equation of state of system with many bi-stable entities—an issue that is rather not easy to understand by any stretch of imagination.

References


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