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ADAPTIVE STANDARD OPERATING PROCEDURES FOR COMPLEX DISASTERS

by

Shawn M. Harwood

March 2017

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This thesis proposes two practical, executable means of integrating adaptability into SOP-driven crisis response. Both options rely on current research in complex adaptive systems theory and a pragmatic application of the Socratic method. The first proposal is the incorporation of adaptability prompts into pre-existing crisis SOPs. These prompts are instructional steps that help emergency responders identify unanticipated behavior during complex events and adjust their crisis response plans accordingly. The second proposal recommends the creation of a crisis co-pilot, an ad hoc advisor who helps the lead emergency responder identify any divergence from predicted behavior and encourages adaptation in the field. To support these policy recommendations, this thesis also presents a computer simulation of air traffic controller responses during the 9/11 attacks, quantifying hypothetical improvements in response times attained by implementing the adaptive design proposals.
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ADAPTIVE STANDARD OPERATING PROCEDURES FOR COMPLEX DISASTERS

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Submitted in partial fulfillment of the
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ABSTRACT

Standard operating procedures (SOPs) guide emergency responders in a crisis, providing predetermined steps to manage anticipated events. Modern disasters, however, often manifest as complex systems—susceptible to nonlinear interactions and feedback in the environment that produce unanticipated outcomes. As a consequence, the application of prediction-dependent SOPs to such prediction-defiant scenarios yields ineffective emergency management. In contrast, case studies suggest that crisis responses demonstrating adaptable behavior often succeed in a complex environment. If adaptability mitigates complex problems, then modern crisis SOPs should embrace an adaptive approach.

This thesis proposes two practical, executable means of integrating adaptability into SOP-driven crisis response. Both options rely on current research in complex adaptive systems theory and a pragmatic application of the Socratic method. The first proposal is the incorporation of *adaptability prompts* into pre-existing crisis SOPs. These prompts are instructional steps that help emergency responders identify unanticipated behavior during complex events and adjust their crisis response plans accordingly. The second proposal recommends the creation of a *crisis co-pilot*, an ad hoc advisor who helps the lead emergency responder identify any divergence from predicted behavior and encourages adaptation in the field. To support these policy recommendations, this thesis also presents a computer simulation of air traffic controller responses during the 9/11 attacks, quantifying hypothetical improvements in response times attained by implementing the adaptive design proposals.

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LIST OF ACRONYMS AND ABBREVIATIONS

ATC	air traffic controller
CAS	complex adaptive systems
FAA	Federal Aviation Administration
FEMA	Federal Emergency Management Agency
HSE	Homeland Security Enterprise
IISIS	Interactive Intelligent Spatial Information Systems
LLCIP	Lessons Learned and Continuous Improvement Program
MAS	multi-agent system
NEADS	Northeast Air Defense Sector
NORAD	North American Aerospace Defense Command
NPAD	National Preparedness Assessment Division
NPD	National Preparedness Directorate
NPS	Naval Postgraduate School
OEMC	Office of Emergency Management and Communications
POEU	Publications Office of the European Union
SEED	Simulation Experiments and Efficient Designs
SOP	standard operating procedure
TEPCO	Tokyo Electric Power Company
USCG	U.S. Coast Guard

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EXECUTIVE SUMMARY

The nature of disasters has evolved, but emergency management has not kept pace with the change. Today's crisis environment is subject to countless influences—a product of our globalized, complex society—which produce random and volatile events. Despite the unpredictability of modern disasters, the Homeland Security Enterprise still adheres to prediction-dependent standard operating procedures (SOPs) to guide emergency response. As a result, police, firefighters, and other crisis professionals are less able to manage complex crises.

A. BACKGROUND

Professional crisis responders perform their duties using four essential tools: professional training, job-specific technology, accumulated work experience, and SOPs.[1] The SOP anticipates the operating environment and provides a checklist of recommended actions to accomplish an objective. Sociologists Charles Parker and Eric Stern claim, "SOPs are based on past experience and expectation."[2] As long as the actual event adheres to the prediction, personnel can rely on the SOP to impart relevant guidance. However, when reality diverges from the anticipated scenario, SOP guidance becomes less useful.

Beginning in the late twentieth century, the global community experienced tremendous improvements in telecommunications and information sharing, allowing agents within this worldwide system to interact with and exert unprecedented influence on each other. This significant increase in connectivity and feedback intensified the *complexity* of many social systems. Sociologists David Snowden and Mary Boone describe complexity as the behavior of large numbers of agents dynamically reacting to

[1] The author bases this statement on 18 years of experience in federal law enforcement as both a criminal investigator and an emergency medical technician.

[2] Charles F. Parker and Eric K. Stern, "Blindsided? September 11 and the Origins of Strategic Surprise," *Political Psychology* 23, no. 3 (2002): 615, doi: 10.111/0162-895X.00300.

and influencing each other within a bounded system.[3] One of the essential characteristics of complexity is that behavioral outcomes often prove non-intuitive and difficult to predict. Modern disasters can also demonstrate complex characteristics, erupting quickly and evolving in unexpected ways.

Modern crises often demonstrate the prediction-defiant characteristics of complexity. To examine these unpredictable characteristics and assess the utility of SOP-driven crisis response vis-à-vis adaptive behavior, this thesis explores three modern crises that demonstrated complex characteristics: the 9/11 attacks, Hurricane Katrina, and the Tohoku Tsunami/Fukushima Dai'ichi nuclear incident. Each of these events exhibited complex characteristics and affords the opportunity to assess both SOP-driven and adaptive responses.

The case studies consistently showed that SOPs provided inadequate guidance in these crises while adaptive approaches would have been more effective in the complex environments in which the crises occurred. When the actual disasters deviated from the prediction, emergency responders found themselves adhering to irrelevant procedures. For instance, as the Federal Aviation Administration (FAA) attempted to follow a hijacking SOP, its officers failed to recognize that the event had become a terror attack. Alternatively, the U.S. Coast Guard successfully supported the maritime evacuation of Manhattan during the 9/11 attacks by consciously departing from SOP guidance. While instances of adaptable behavior did not significantly mitigate these crises, they serve to illustrate the advantages of adaptive behavior approaches over rote, SOP-driven responses in the complex environment.

B. THE ADAPTIVE DESIGN PROPOSALS

The fundamental weakness in SOP guidance for complex crises is its static approach to a variable environment. To mitigate this vulnerability, SOP-driven crisis response must pivot to embrace an adaptive posture. Toward that end, the thesis recommends two methods to integrate adaptability into SOP-driven crisis response.

[3] David J. Snowden and Mary E. Boone, "A Leader's Framework for Decision Making," *Harvard Business Review* 85, no. 11 (2007).

These proposals make use of contemporary research into complex adaptive systems (CAS) theory and a practical application of the Socratic method to the emergency response paradigm.

Louise Comfort et al. describe the essential nature of CAS as “the spontaneous reallocation of energy and action to achieve a collective goal in a changing environment.”[4] Essentially, CAS describes the adaptive behavior that agents must demonstrate to achieve their objectives within a complex system. The ability to engage in flexible, dynamic responses to unexpected deviations is necessary, particularly when navigating the hazardous environment of a complex disaster. Similarly, Mary Uhl-Bien, Russ Marion, and Bill McKelvey contend that emergency responders must function as a CAS, following a course dictated by a dynamic interaction with the environment rather than by bureaucratic protocols.[5]

The Socratic method is a particularly relevant tool for emergency response in a complex crisis as it promotes an active search for knowledge to achieve comprehension. Its emphasis on challenging assumptions and re-evaluating a problem prepares emergency responders to expect an evolving scenario. Therefore, it is an ideal foundation to develop a dynamic process for succeeding in a complex environment.

The first proposal is the incorporation of *adaptability prompts* into pre-existing crisis SOPs. Based on the Socratic method, these prompts urge emergency responders to challenge their assumptions about the crisis event and continually seek a better way to achieve their objectives. These instructional steps help identify unanticipated events or behaviors in the field and adjust the crisis response plans accordingly. The proposal of adaptability prompts is a simple upgrade to pre-existing SOPs that urges awareness of complexity and promotes adaptive behavior.

[4] Louise K. Comfort et al., “Complex Systems in Crisis: Anticipation and Resilience in Dynamic Environments,” *Journal of Contingencies and Crisis Management* 9, no. 3 (2001): 146.

[5] Mary Uhl-Bien, Russ Marion, and Bill McKelvey, “Complexity Leadership Theory: Shifting Leadership from the Industrial Age to the Knowledge Era,” *The Leadership Quarterly* 18, no. 4 (2007).

Patrick Lagadec and Benjamin Topper recommend the provision of cognitive assistance during an emergency.[6] Their analysis suggests that leading emergency response actions in the field while constantly evaluating the crisis environment is a task that may exceed the capacity of a single crisis professional. To accommodate this dilemma, the second proposal recommends the creation of a *crisis co-pilot*, an ad hoc advisor who helps the lead emergency responder identify any divergence from predicted behavior and encourages adaptation in the field. Essentially, the crisis co-pilot assists the lead emergency responder in adhering to the Socratic tenets recommended by the adaptability prompts, reminding him to challenge initial expectations in the crisis scenario and adapt the operational plan to accommodate the unexpected.

C. A COMPUTER SIMULATION TO SUPPORT THE ADAPTIVE DESIGN PROPOSALS

A multi-agent computer simulation is a framework for approximating human decisions within a virtual system to identify the best means for a desired outcome. The computer simulation cannot represent every nuance in human behavior or unpredicted influences in a complex system, so experimental conclusions appear as "if/then" statements rather than concrete assertions. While these results are only hypothetical, they can effectively promote or denigrate a policy proposal by quantifying and depicting its potential value. To illustrate the potential benefit of the adaptive design proposals, the thesis presents a computer simulation based on the FAA response on the morning of September 11.

The simulation experiment approximated the hypothetical value of the adaptive design proposals by incrementally increasing the FAA's ability to detect the first hijacked airliner on 9/11 as a threat. The goal of this experiment—the point at which the adaptive design proposals achieve a meaningful improvement in the scenario outcome—was to prompt the order to launch alert fighters in time to intercept the second hijacked airliner before it struck the World Trade Center. The outcome of the experiment suggests that if the adaptive design proposals yielded a 25 percent improvement in FAA threat detection,

[6] Patrick Lagadec and Benjamin Topper, "How Crises Model the Modern World," *Journal of Risk Analysis and Crisis Response* 2, no. 1 (2012): 28.

the fighters could have intercepted the second airliner. These results, therefore, may be more broadly construed to indicate that the adaptive design proposals could yield a significant benefit to the field of crisis response.

D. CONCLUSION

While ineffective SOPs do not presuppose the failure of emergency responders in every complex event—the quality of their experience and technology arguably overshadows the shortfalls of these static guidelines—they remain a flawed yet fixable problem within the emergency response field. As such, this thesis proposed two executable methods to integrate adaptability into SOP-driven emergency response. By incorporating adaptability prompts into crisis SOPs and instituting the role of a crisis co-pilot, response agencies can more effectively manage complex emergencies. Further, by implementing these steps to integrate adaptability into standardized emergency response, crisis professionals can better manage complex disasters and, in doing so, better protect their communities.

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I’m confident there are more names that deserve inclusion in this letter, so I apologize in advance for neglecting anyone. This entire experience has been an extraordinary, collaborative process. Last, but never least, I want to thank my cohort, my academic family, my 1511—you people challenged and changed me for the better. I wish you every success and happiness in the future.

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I. INTRODUCTION

The nature of disasters has evolved, but emergency management has not kept pace with the change. Today's crisis environment is subject to countless influences—a product of our globalized, complex society—which produce random and volatile events. Despite the unpredictability of today's crisis arena, the Homeland Security Enterprise (HSE) still adheres to prediction-dependent standard operating procedures (SOPs) to guide emergency response. As a result, police, firefighters, and other crisis professionals are less able to manage modern, unpredictable events.

A. PROBLEM STATEMENT

Professional crisis responders perform their duties using four essential tools: professional training, job-specific technology, accumulated work experience, and SOPs.[1] The SOP anticipates the operating environment and provides a checklist of recommended actions to accomplish an objective. Sociologists Charles Parker and Eric Stern claim, "SOPs are based on past experience and expectation."[2] As long as the actual event adheres to the prediction, personnel can rely on the SOP to impart relevant guidance. However, when reality diverges from the anticipated scenario, crisis professionals find that SOP direction becomes less useful.

Beginning in the late twentieth century, the global community experienced tremendous improvements in telecommunications and information sharing, allowing agents within this worldwide system to interact with and exert unprecedented influence on each other. This significant increase in connectivity and feedback increased the *complexity* of many social systems. Sociologists David Snowden and Mary Boone describe complexity as a way of understanding the behavior of large numbers of agents

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dynamically reacting to and influencing each other within a bounded system.[3] One of the essential characteristics of complexity is that behavioral outcomes often prove non-intuitive and difficult to predict. Modern disasters can also demonstrate complex characteristics, erupting quickly and evolving in unexpected ways.

If SOPs are designed to respond primarily to predictable scenarios, their value is diminished when mitigating complex disasters with unpredictable outcomes. This is a dilemma with which present-day crisis professionals must contend in the field. This thesis addresses how to integrate adaptability into SOPs to improve their value as tools for mitigating complex disasters. The research and analysis should yield executable solutions with which HSE policy makers can upgrade traditional SOPs to promote adaptability, thereby allowing more effective emergency responses in the age of complexity.

B. RESEARCH QUESTION

How can we integrate adaptability into standard operating procedures?

The thesis recommends two potential solutions to the issues presented in the problem statement. These proposals depend on the argument that success in a complex environment requires adaptability. Therefore, successful emergency response in a complex disaster requires an adaptive approach. This work explores the feasibility and methods policy makers within the HSE can use to incorporate adaptability into the traditionally static SOP model. To develop the adaptive modification proposals for the crisis SOP, this thesis makes use of contemporary research into complex adaptive systems theory and a practical application of the Socratic method to the emergency response paradigm.

3 David J. Snowden and Mary E. Boone, "A Leader's Framework for Decision Making," *Harvard Business Review* 85, no. 11 (2007).

C. LITERATURE REVIEW

The research presented in this work illustrates the diminished value of prediction-dependent SOPs in complex crises and proposes redesigning the SOP model by integrating adaptability into the emergency response process. Very little literature explores the effectiveness of crisis response SOPs in complex environments. Therefore, it was necessary to conduct research to develop and evaluate this notional problem across a broad range of topics, from complexity theory to the origin and evolution of SOPs, to empirical and analytical assessments of modern, complex disasters. The following pages discuss the key resources used to define the problem as well as to develop and evaluate a proposed solution for addressing the limited value of prediction-dependent SOPs in complex crises.

1. The Era of Complexity

There is an abundance of literature on the increase of complexity in today's environment. Leadership experts Mary Uhl-Bien, Russ Marion, and Bill McKelvey provide significant insight into the evolution of complexity in the modern era. They argue that prior to the technological revolution, organizational relationships tended toward linear connections, thereby limiting the influence that human and non-human elements within a system exerted on each other.[4] While these systems could have many connected agents, their relationships were straightforward and predictable. This type of environment is known as a *complicated* system.

In contrast, a *complex* system comprises agents who influence each other in a nonlinear or random fashion, making the outcome of their interactions far less predictable. Recent technological improvements have created a new era of high-velocity communication, interdependent infrastructures, and immediate data access. These global networks allow agents from around the world to influence each other in diverse ways, establishing the unpredictable characteristics of complexity in the modern environment.[5]

[4] Mary Uhl-Bien, Russ Marion, and Bill McKelvey, "Complexity Leadership Theory: Shifting Leadership from the Industrial Age to the Knowledge Era," *The Leadership Quarterly* 18, no. 4 (2007).

[5] Ibid.

The works of Snowden and Boone, as well as General Stanley McChrystal et al., describe the significant influence of elements interacting within an environment. Snowden and Boone developed the *Cynefin Framework*, a classification system that defines the nature of an environment as ordered, unordered, or disordered.[6] Further, their framework depicts the contrasting characteristics of the linear, predictable complicated system against the nonlinear, unpredictable complex system. McChrystal et al. discuss the challenges of decision making in a complex crisis environment, as they analyze the successes and failures of the military campaign against al Qaeda in Iraq.[7]

2. The Standard Operating Procedure

Such peer-reviewed works as Michael Gunther's "Auftragstaktik: The Basis for Modern Military Command?" identify the origins of the formalized SOP in nineteenth century Germany.[8] Von Moltke designed the original SOP for an ordered, linear environment, and the tenets of his methodology were also successfully applied on the factory production floor during the Industrial Age. Robert Kanigel's article on Frederick Winslow Taylor and the industrial efficiency movement provides an example of how an ordered, predictable environment is the optimal setting for the SOP model.[9]

Businesses that operate in complex environments are subject to many diverse influences, some harmful and some helpful. There is significant research material available on the modern business approach to globalized vulnerabilities. Economists Ila Manuj and John Mentzer discuss the impact of complexity on the global marketplace.[10] They argue that successful modern companies take advantage of the dynamic business opportunities created by the complex domain's interconnectivity and globalization.

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[6] Snowden and Boone, "A Leader's Framework," 68–77.

[7] Stanley McChrystal et al., *Team of Teams: New Rules of Engagement for a Complex World* (London: Penguin, 2015).

[8] Michael J. Gunther, "Auftragstaktik: The Basis for Modern Military Command?" (Monograph, School for Advanced Military Studies, 2012).

[9] Robert Kanigel, "Taylor-made," *The Sciences* 37, no. 3 (1997): 19, doi: 10.1002/j.2326-1951.tb03309.x.

[10] Ila Manuj and John T. Mentzer, "Global Supply Chain Risk Management," *Journal of Business Logistics* 29, no. 1 (2008): 133, doi: 10.1002/j.2158-1592.2008.tb00072.x.

Additionally, the Publications Office of the European Union defines the interdependence and connectivity between lines of programming code in a computer application. An effective SOP must accommodate the elements of complexity in the implementation of any software upgrade.[11]

There is considerable material on modern crisis-response SOPs, varying from non-specific guidelines to specific checklist-style examples. The checklist protocol for police officers responding to an active shooter sharply contrasts with the modern business SOP; the police model fails to acknowledge the likelihood of unanticipated influences in the scenario. Instead, the police example assumes that active shooters behave in predictable ways. Psychologist Daniel Kahneman provides an interesting counterpoint to the suggested problem caused by ineffective SOPs. He theorizes that the "everyday" experience of emergency responders refines their decision-making acumen to an instinctive level. This reflexive response enables some crisis professionals to react swiftly and effectively to unanticipated developments, despite ineffective SOP guidance.[12] Kahneman argues that a veteran crisis responder relies primarily on experience, rendering SOP guidance irrelevant.

3. Case Studies—Complexity in Modern Crises

To examine unpredictable characteristics in the modern crisis environment and assess the utility of SOP-driven crisis response compared to adaptive (i.e., non-SOP) behavior, this research explores case studies of three modern crises that demonstrated complex characteristics: the September 11 terror attacks, Hurricane Katrina, and the Fukushima-Dai'ichi nuclear disaster. Analysis of these mega-crises demonstrated the value of both SOP-driven actions and adaptive responses, and identified the reasons why these actions succeeded or failed in a complex crisis.

[11] Publications Office of the European Union, *Technical Environment and Standard Operating Procedures of the Publications Office: Annex 12*, Version 3.1 (Luxembourg: Publications Office of the European Union: March 2012), 17, https://publications.europa.eu/documents/10530/676542/ao_10477_annex_12_en.pdf.

[12] Daniel Kahneman, *Thinking, Fast and Slow* (London: Macmillan, 2011), 236–237.

a. September 11 Terror Attacks

The National Commission on Terrorist Attacks and the University of Maryland's "Background Report: 9/11, Ten Years Later" provide objective descriptions of decision making and crisis response on the day of the attacks.[13] Resource literature produced by James Kendra and Tricia Wachtendorf analyzes SOP-driven actions during the September 11 attacks.[14] Kathleen Tierney's research on behalf of the University of Delaware's Disaster Research Center compares prediction-dependent responses to flexible, adaptive action during this crisis.[15]

b. Hurricane Katrina

The material produced by the U.S. House of Representatives furnishes an objective description of the Katrina disaster.[16] Economists Russell Sobel and Peter Leeson contribute a unique analysis of crisis events, directly comparing the decentralized disaster responses during the September 11 attacks to the response after Hurricane Katrina.[17]

c. Tohoku Tsunami and Fukushima-Dai'ichi Meltdown

Articles written by Nobuhito Mori, Tomoyuki Takahashi, Tomohiro Yasuda, and Hideaki Yanagisawa provide synopses of the Fukushima-Dai'ichi disaster.[18] Research

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[13] National Commission on Terrorist Attacks upon the United States, *The 9/11 Commission Report: Final Report of the National Commission on Terrorist Attacks upon the United States* (Authorized Edition) (New York: W. W. Norton, 2004), 18; National Consortium for the Study of Terrorism and Responses to Terrorism, "Background Report: 9/11, Ten Years Later," University of Maryland, 2011, https://www.start.umd.edu/sites/default/files/files/announcements/BackgroundReport_10YearsSince9_11.pdf.

[14] James Kendra and Tricia Wachtendorf, "Creativity in Emergency Response to the World Trade Center Disaster" (Special Publication No. 39, University of Colorado, 2003), 127.

[15] Kathleen Tierney, "Conceptualizing and Measuring Organizational and Community Resilience: Lessons from the Emergency Response Following the September 11, 2001 Attack on the World Trade Center," (Preliminary Paper #329, University of Delaware, 2003), 5.

[16] U.S. House of Representatives, A *Failure of Initiative: The Final Report of the Select Bipartisan Committee to Investigate the Preparation for and Response to Hurricane Katrina* (Washington, DC: U.S. Government Printing Office, 2006).

[17] Russell S. Sobel and Peter T. Leeson, "Government's Response to Hurricane Katrina: A Public Choice Analysis," *Public Choice* 127, no. 1–2 (2006): 55–73.

[18] Nobuhito Mori et al., "Survey of 2011 Tohoku Earthquake Tsunami Inundation and Run-up," *Geophysical Research Letters* 38, no. 7 (2011).

scientists Okada Norio, Tao Ye, Yoshio Kajitani, Peijun Shi, and Hirokazu Tatano summarize the relative efficacy of SOP-driven responses during the disaster, providing both insightful analysis and significant technical detail.[19] Additionally, analysis produced by Eliza Strickland on behalf of the Institute of Electrical and Electronics Engineers discusses the nuclear plant's SOPs as well as the inherent value of the employees' adaptive responses in the crisis.[20] An article written by Robert Geller, Woody Epstein, and Johannis Noggerath explains the limitations of the nuclear plant's SOPs and the associated crisis planning.

4. Building the Adaptable SOP Model

The works of Louise Comfort et al. and Mary Uhl-Bien et al. address the challenges of public management in complex environments, particularly in relation to natural or manmade disasters.[21] The design concepts for the adaptable SOP model depend heavily on the dialectic principles of the Socratic method. This thesis relies significantly on the scholarly contributions of Linda Elder and Richard Paul as well as T. Rick Whiteley. Their published works discuss the methodology behind Socratic questioning, which forms a basis for the adaptive design proposals recommended in the thesis.[22] Finally, material published by Patrick Lagadec and Benjamin Topper addresses the challenges of mitigating complex crises. The authors make the central claim that decision making in modern crisis response demands a paradigm shift toward adaptive, creative thinking to manage the attributes of complexity.[23]

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[19] Okada Norio et al., "The 2011 Eastern Japan Great Earthquake Disaster: Overview and Comments," 2, no. 1 (2011), http://link.springer.com/journal/13753.

[20] Eliza Strickland, "24 Hours at Fukushima: A Blow-by-Blow Account of the Worst Nuclear Accident Since Chernobyl," IEEE Spectrum, October 31, 2011, http://spectrum.ieee.org/energy/nuclear/24-hours-at-fukushima.

[21] Louise K. Comfort et al., "Complex Systems in Crisis: Anticipation and Resilience in Dynamic Environments," *Journal of Contingencies and Crisis Management* 9, no. 3 (2001): 144–158; Uhl-Bien, Marion, and McKelvey, "Complexity Leadership Theory."

[22] Linda Elder and Richard Paul, "The Role of Socratic Questioning in Thinking, Teaching, and Learning," *The Clearing House* 71, no. 5 (1998); T. Rick Whiteley, "Using the Socratic Method and Bloom's Taxonomy of the Cognitive Domain to Enhance Online Discussion, Critical Thinking, and Student Learning," *Developments in Business Simulation and Experiential Learning* 33 (2014).

[23] Patrick Lagadec and Benjamin Topper, "How Crises Model the Modern World," *Journal of Risk Analysis and Crisis Response* 2, no. 1 (2012): 21–33.

5. Evaluating the Adaptable SOP

There is a wealth of available literature on the value of running computer simulations to test policies and operational plans before implementing them. Susan Sanchez and Li An discuss the merits and design necessities of computer simulations. Sanchez speaks to the fundamental attributes of experimental design and its value in exploring environmental factors in simulation rather than real-time attempts through trial and error.[24] Both authors describe methods to optimize the design and execution of computer simulation models.

D. RESEARCH DESIGN AND METHODS

The goals of this research are to identify a vulnerability in the crisis-response application of SOPs in complex environments and recommend a method to resolve the deficiency. To accomplish these goals, this thesis focuses on three objectives: 1) to identify the problem, specifically the history and evolution of the SOP model and the characteristics and relevance of complexity in modern crises; 2) to assess the diminished value of prediction-dependent SOP guidance in complex emergencies; and 3) to construct and evaluate a more adaptive SOP design that policy makers can implement within the framework of existing emergency response SOPs. Ideally, this work will convince HSE leadership to enhance existing SOPs to address the unpredictability of complex emergency events.

1. Selection of Resource Material

To accomplish the stated objectives, this thesis relies on material obtained through open-source research as well as proprietary sources accessed via the Dudley Knox Library at the Naval Postgraduate School. The literature includes material from governmental documents and peer-reviewed articles and books. The thesis also makes

[24] Susan M. Sanchez, “Work Smarter, Not Harder: Guidelines for Designing Simulation Experiments,” *Proceedings of the 37th conference on Winter Simulation* (2005): 69–82; Li An, “Modeling Human Decisions in Coupled Human and Natural Systems: Review of Agent-Based Models,” *Ecological Modelling* 229 (2012): 25–36.

use of local, state, and federal policy documents that have identified various SOP models employed in the management of emergency events.

2. Research Methodology

This thesis embraces a *policy analysis* research design to examine the efficacy of crisis response SOPs in complex scenarios. First, the thesis clarifies the principal components of a crisis, explaining how the prediction-dependent SOP functions within a complex operational setting. The thesis then explores the characteristic unpredictability of complex environments and its cause. The work also considers the origins of the SOP in the complicated operational setting and its relative evolution within the modern, complex operational setting. The thesis further explains the opposing characteristics of these two operational domains by contrasting the linear and predictable relationships of agents in the complicated realm against the nonlinear—and therefore unpredictable—relationships of agents in the complex realm.

The thesis examines the modern, complex crisis environment by conducting case studies of three significant complex crises: the September 11 terror attacks, Hurricane Katrina, and the Fukushima-Dai'ichi nuclear meltdown. These rely on empirical accounts and peer-reviewed analysis to study the interactions of crisis responders within the complex crisis environment. Analysis of the case studies identified successful and unsuccessful response practices within these complex disasters. Specifically, the analysis connected the responders' relative success or failure in mitigating complex emergency scenarios with their ability to manage unpredictable events.

After comprehensively exploring and analyzing the weaknesses of the existing SOP model, the work recommends a method to resolve these complexity-driven limitations. The thesis contends that integrating adaptability into the SOP model will make SOP-driven crisis response more relevant and effective in the complex environment. After discussing the potential value of the adaptive design proposals, the thesis presents potential methods to implement these recommendations within the HSE crisis response arena. Subsequent to the discussion of the adaptive design proposals, this work discusses the value of multi-agent system (MAS) computer simulations as decision support tools. The thesis then presents an actual MAS experiment designed and executed to evaluate the potential impact of an adaptive SOP in a complex crisis environment.

3. Output

If crisis professionals depend on predictive SOP guidance, modern emergency response is weakened by the unpredictability of complex events. To counter this vulnerability, policy makers should consider modifying the traditional SOP-driven approach to emergency management by promoting adaptability as a countermeasure to complexity. The intended output of this thesis is the proposal of executable solutions to remedy the identified flaws in today's emergency response paradigm. This work should convince HSE policy makers of the need to address complexity in emergency management and provide a practical means to achieve that goal.

E. CHAPTER OUTLINE

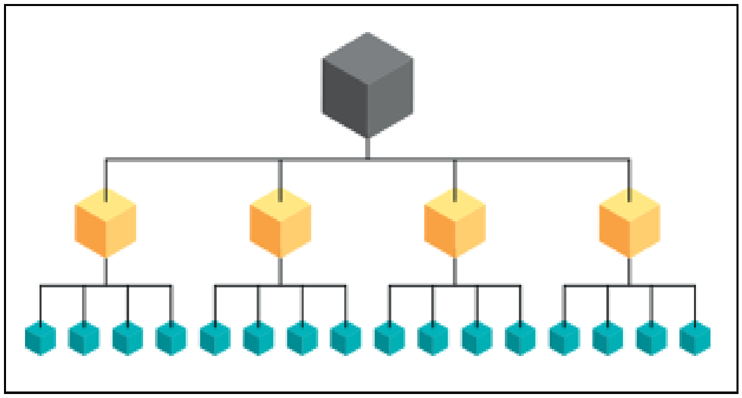
The following chapters explore the notional challenges of prediction-dependent SOPs applied to unpredictable, complex disasters. Chapter II examines the origins of the SOP and the nature of complexity theory. Chapter III explores case studies of modern crises to evaluate the effectiveness of emergency response SOPs in action—assessing what worked and what did not. Chapter IV proposes two methods to integrate adaptability into the "traditional" SOP model. These adaptive SOP modifications are based on the principal conclusion that unpredictable crisis environments demand an adaptable approach to emergency response. Finally, Chapter V presents the results of a computer simulation that illustrates the hypothetical improvements crisis responders could achieve by implementing the adaptive SOP proposals.

II. THE DISASTER DILEMMA: COMPLEXITY VERSUS PREDICTION

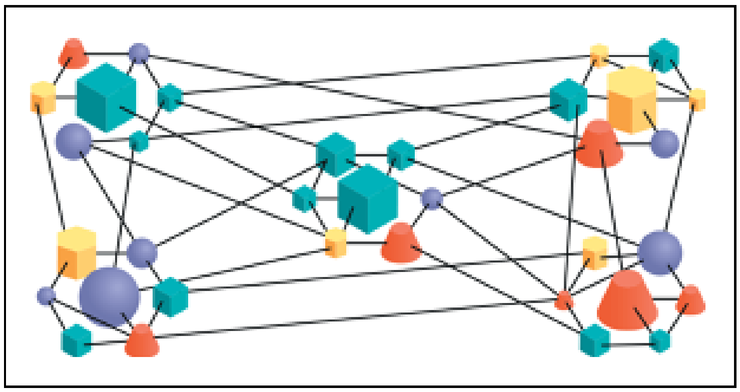
A. THE ERA OF COMPLEXITY

Toward the end of the twentieth century, connectivity in the human environment increased substantially through improvements in telecommunications, Web-based information sharing, and electronic connections between business and government infrastructures. As Mary Uhl-Bien et al. state, "21st century organizations are facing a complex competitive landscape driven largely by globalization and the technological revolution."[25] Prior to these advancements, organizational relationships had more linear connections, limiting the influence that human and non-human elements within a system could exert on each other. While a significant number of factors influenced a complicated working environment, their linear relationships often yielded an orderly, predictable outcome. Figure 1 illustrates the difference between a complicated and a complex system. The technological improvements of the twenty-first century have introduced a new era of global networks, interdependent infrastructures, and high-velocity communication, which, in turn, has increased the incidence of complexity in the environment.

[25] Uhl-Bien, Marion, and McKelvey, "Complexity Leadership Theory," 299.



Complicated System



Complex System

Figure 1. Complicated System versus Complex System[26]

Connectivity in a complex environment allows a multitude of elements within a common system to influence each other, producing scenarios and outcomes that defy long-term prediction. As Bruce MacLennan states, “Complex systems manifest emergent properties, which cannot be explained in terms of simple, linear interactions among the system’s components.”[27] These emergent events and outcomes are the by-products of nonlinear reactions to other agents within the system. Sociologists David Snowden and Mary Boone further clarify the significant influence of elements interacting within a complex system: “The interactions are nonlinear, and minor changes can produce

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[26] Adapted from Stanley McChrystal et al., “Let General Stanley McChrystal Explain Why Adaptability Trumps Hierarchy,” FastCompany, May 12, 2015, https://www.fastcompany.com/3045477/work-smart/goodbye-org-chart.

[27] Bruce MacLennan, “Evolutionary Psychology, Complex Systems, and Social Theory,” *Soundings* 90, no. 3/4 (2007): 172.

disproportionately major consequences."[28] The principles of complexity apply to the modern crisis environment as well. As General Stanley McChrystal et al. describe, "New technologies have created an unprecedented proliferation of opportunities for small, historically disenfranchised actors. … Terrorists, insurgents, and cybercriminals have taken advantage of speed and interdependence to cause death and wreak havoc. But it *all* exhibits the unpredictability that is a hallmark of complexity."[29] McChrystal et al. claim that man-made disasters can exhibit the characteristics of a complex system; for instance, terrorist groups can coordinate or adjust attack strategies with a cellular telephone from anywhere on the planet. Likewise, the connectivity among civil infrastructure creates a complex system vulnerable to natural disasters. For example, storm-related damage to a local power grid can cause overload and failure in adjacent power grids, resulting in widespread blackouts and cascading infrastructure collapses in dependent civil services.

1. The Cynefin Framework

Today's application of the standard operating procedure (SOP) depends on accurate predictions of the operating environment to recommend the ideal steps to accomplish mission goals. Therefore, an SOP works best in an ordered setting where the various elements at work have simple, linear influence on each other. This state of order produces a stable environment in which policy makers can effectively project the operational scenario. Picture the analogy of a toy car on an assembly line: each phase of the production process adds a new piece to the product without any outside influences. Each stage is a preordained step in the SOP; one can easily predict the end result of a completed toy because there are few factors influencing the process. Snowden and Boone developed a structure to depict the relationship of influences on elements within a system, the Cynefin Framework (see Figure 2).[30]

[28] David J. Snowden and Mary E. Boone, "A Leader's Framework for Decision Making," *Harvard Business Review* 85, no. 11 (2007): 71.

[29] McChrystal et al., *Team of Teams*, 61–62.

[30] Snowden and Boone, "A Leader's Framework," 68–77.

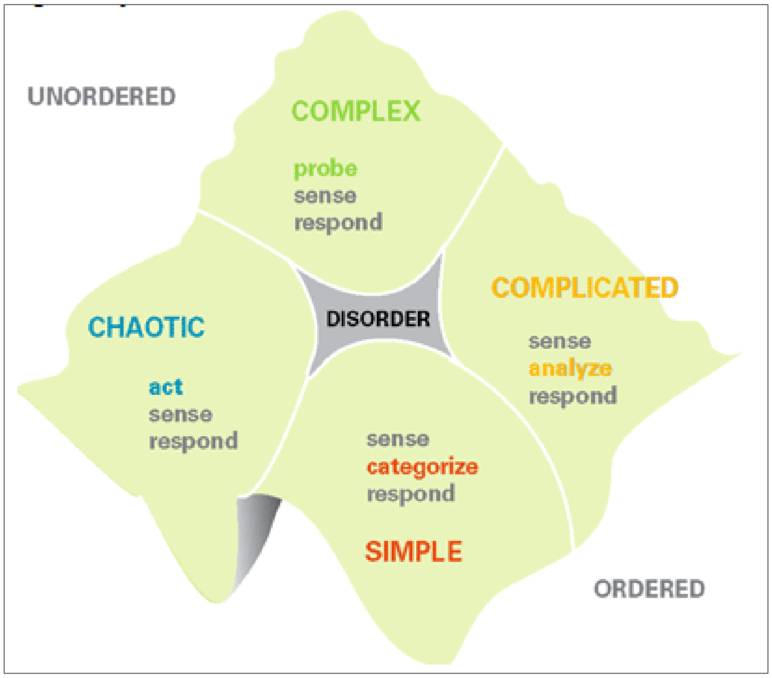

Figure 2. Cynefin Framework[31]

The first two domains of the Cynefin Framework are *simple* and *complicated*, both of which describe ordered environments where relationships between system elements are observable and outcomes are predictable. The simple context is alternatively described as “obvious” because the relationship between factors is evident, as in the toy car example. The complicated domain has more factors at work within a common system, but the interaction of these factors is also linear and the outcome remains predictable, as illustrated in Figure 1. The inherent predictability of these domains creates the optimal environment for an SOP.

The *complex* domain is an interconnected, fast-paced environment. Characteristics of complexity exist in the twenty-first century global business arena, in unconventional military engagements, and in the emergency response field. While complex environments are far less predictable than complicated environments, decision makers are able to identify consistent patterns in the complex domain through trial and error, enabling them to make effective choices in the field. The fourth domain in the framework is *chaotic*,

[31] Source: Ibid.

representing an environment of patternless “turbulence” that Snowden and Boone compare to the immediate aftermath of the September 11 plane impacts.[32] In this unstable setting, decision makers are unable to pre-plan their tactics; they can only react to elements within the scenario in an attempt to “transform the situation from chaos to complexity, where the identification of emerging patterns can both help prevent future crises and discern new opportunities.”[33] The fifth and final domain in the Cynefin Framework is *disorder*, a predicament that confounds decision makers with an unmanageable environment. Disorder defies any effort to identify patterns or characteristics that might be consistent with the other four domains.

2. Complex Adaptive Systems

As Snowden and Boone state, minor influences in a complex environment can significantly impact the stability of the entire system.[34] This is particularly relevant during crisis responses as the interaction of various elements can quickly force the actual event to evolve away from the predicted or anticipated outcome, which reduces the effectiveness of SOP guidance. In a changing crisis environment, emergency responders are more likely to achieve successful results by assuming a flexible approach.

Modern sociologists are developing a discipline that studies complexity, its application to human systems, and the role of adaptability in successfully operating within a complex environment.[35] This analytical field is called complex adaptive systems (CAS), and it has significant implications for the future of emergency planning and disaster response. CAS research applied to emergency management pursues a number of diverse paths, from self-organizing emergency response among the private sector (emergent groups) to intelligent technology that interprets crisis events and recommends

[32] Ibid.

[33] Ibid., 74.

[34] Ibid., 68–77.

[35] Glenda Eoyang, “Complex Adaptive Systems CAS,” presented at The Kellogg Foundation, May 2004, http://www.bobwilliams.co.nz/Systems_Resources_files/CASmaterial.pdf.

mitigation responses (Interactive, Intelligent, Spatial Information Systems).[36] There are many different aspects of CAS research, but they universally promote adaptability and diminish reliance on inflexible principles such as those that make up the SOP model. Bolton and Stolcis also argue for the application of adaptability in disaster response "when a crisis is imminent or occurring and individual agents … need the freedom and flexibility to depart from traditional hierarchical management practices, take risks, and draw upon their imaginations."[37] As demonstrated by experienced crisis professionals choosing to diverge from an SOP, CAS research also supports the argument that complex crises demand adaptable, innovative responses.

B. THE STANDARD OPERATING PROCEDURE

The formal use of SOPs appears to have first developed in nineteenth century Germany as a military strategy championed by German Field Marshall Helmuth Karl Bernhard Graf von Moltke.[38] Von Moltke's theory of *auftragstaktik* translates as "mission strategy," and was a process by which military leaders developed mission goals into specific tasks based around a particular event.[39] This concept revolutionized the military approach to command and control by allowing commanders to write a set of orders that encompassed the overall mission while tailoring specific instructions for subordinates to execute in the field. Arguably, modern U.S. military strategy derives from von Moltke's *auftragstaktik* principles.

The use of SOPs has remained a principal management tool for more than 150 years because it offers significant benefits as a guide for personnel expected to operate in the field without supervision. Today's government agencies and private companies generally characterize an SOP as an official document that predicts the operating environment and provides a checklist of recommended actions that conform to agency

[36] Kendra and Wachtendorf, "Creativity in Emergency Response"; Comfort et al., "Complex Systems in Crisis," 144–158.

[37] Michael J. Bolton and Gregory B. Stolcis, "Overcoming Failure of Imagination in Crisis Management: The Complex Adaptive System," *The Innovation Journal* 13, no. 3 (2008): 10.

[38] "The Value of Standard Operating Procedures," Mosaic, October 22, 2012, http://www.mosaicprojects.com.au/WhitePapers/WP1086_Standard_Operating_Procedures.pdf.

[39] Gunther, "Auftragstaktik."

policy. The Environmental Protection Agency defines the purpose of an SOP as a document that "minimizes variation and promotes quality through consistent implementation of a process or procedure within the organization. … Ultimately, the benefits of a valid SOP are reduced work effort, along with improved comparability, credibility, and legal defensibility."[40] The SOP model seeks consistency in executing mission goals by promoting rote behavior.

1. The Clockwork SOP

While the employment of SOPs originated in a military environment, they also exist in the business realm to accomplish the same basic goals: consistent quality, labor efficiency, and a safe work setting. Frederick Winslow Taylor, the "father of scientific management," contributed to industrial efficiency in the late nineteenth and early twentieth centuries.[41] As a business consultant, he stressed that economy of motion was the key to efficient production. The SOPs he designed for industrial production increased output tremendously. He accomplished these improvements not through better technology but by standardizing an employee's optimal efficiency of motion. Taylor implemented changes to the industrial assembly line to perfect rote performance and eliminate individualized production methods based on experience or creativity. Taylor demanded that every worker complete each task within a certain amount of time and follow specific instructions: "Set tire on machine ready to turn. … Rough face front edge. … Finish face front edge. … Rough bore front. … Finish bore front."[42] Within the linear environment of a factory production floor—the simple domain in Snowden's Cynefin Framework—Taylor's optimization SOPs drastically improved production results.[43] His methods also significantly reduced costs and manpower requirements. Taylor proved that in the ordered environment, a meticulous SOP provided effective guidance, because there was no need for individuality or creativity among his laborers.

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[40] Environmental Protection Agency, Guidance for Preparing Standard Operating Procedures (SOPs) (EPA 600/B-07-001) (Washington, DC: Office of Environmental Information, 2007), 1–2, https://www.epa.gov/sites/production/files/2015-06/documents/g6-final.pdf.

[41] Mary Ellen Papesh, "Frederick Winslow Taylor," (Class paper, St. Francis University, 2000).

[42] Kanigel, "Taylor-made," 19.

[43] Ibid.

2. The Complex Business SOP

Modern companies can take advantage of dynamic business opportunities created by the complex domain's interconnectivity and globalization. Economists Manuj and Mentzer explain, "Due to demanding customers and competitive pressures, businesses today are restructuring themselves to operate on a global basis to take advantage of the international product, factor, and capital markets."[44] However, the consequence for competing in an unpredictable environment is exposure to fluctuations among diverse, nonlinear business relationships. Consider the hypothetical example of a small technology company based in Roanoke, Virginia. Despite its remote location, this business can take advantage of today's complex market to obtain electronic components from India, production software and technical support from Germany, and financing from Switzerland. While these choices may provide the company with superior options in cost and production efficiency, the company is vulnerable to problems that impact its suppliers around the world. Therefore, the business should devise an SOP that respects the *hyper-connected* nature of complexity and accommodates the impact of unexpected influences on its business operation. The following example from the computer software industry illustrates the complex business SOP.

The computer industry's installation process for software updates is a complex business SOP. The software manager's goal is to produce optimal product quality delivered in an effective manner. The interdependence and connectivity between lines of programming code in a computer application exhibits characteristics of complexity. Lines of programming code interact with each other in a nonlinear fashion to produce the intended service of the software program. Christopher Myers describes computer code as a complex system: "Software is built up out of many interacting units and subsystems at many levels of granularity … and the interactions and collaborations of those pieces can be used to define … a system."[45] The hyper-connectivity within software operating

[44] Manuj and Mentzer, "Global Supply Chain Risk Management," 133.

[45] Christopher R. Myers, "Software Systems as Complex Networks: Structure, Function, and Evolvability of Software Collaboration Graphs," *Physical Review E* 68, no. 4 (2003): 046116-1, doi: 10.1103/PhysRevE.68.046116.

systems allows for unpredictable outcomes as small errors can lead to cascading problems and even system collapse.

To accommodate elements of complexity in the software environment, implementation SOPs require test modes as the first step in mitigating prediction-defiant system issues. For instance, the Publications Office of the European Union (POEU) regulates the implementation of new computer code: “No software installation in the production environment will be allowed without prior validation in the test environment.”[46] This SOP promotes the trial-and-error process used to identify successful operating methods in the complex domain, as described in the previous section’s discussion of the Cynefin Framework. To manage concerns over process errors, the POEU’s installation SOP requires procedures that “check the correct installation/working of the application.”[47] The principal objective in the modern business SOP is to organize a consistent procedure that emphasizes awareness of the hyper-connectivity within the complex system and continually reevaluates the operating environment for unexpected influences.

3. The Modern Crisis SOP

Law enforcement, as a part of the Homeland Security Enterprise (HSE), seeks a similar consistency in the “product” of its assigned duties. Procedures that define emergency response to a crisis vary widely among agencies; some provide specific checklist instructions to guide field officers and others provide loose frameworks. As shown in Figure 3, the Chicago Police Department’s Active Shooter Incident Plan exemplifies a highly specific crisis SOP for police officers.

46 Publications Office of the European Union, *Technical Environment and SOPs*, 17.

47 Ibid., 21.

Upon being assigned to an Active Shooter Incident, the first sworn Department member (regardless of rank) arriving on the scene will:

1. Verify that there is a bona fide Active Shooter Incident taking place.
2. Request assistance through the Office of Emergency Management and Communications (OEMC).
3. Determine the location of the incident, suspect description and actions, and type(s) of weapon(s) used and immediately communicate that information to responding units.
4. Immediately upon the arrival of the first assist units, form a contact strike team, enter the location of the incident, as a team, and begin an active search to locate, isolate, secure, and neutralize the assailant(s).

NOTE: These duties need to be completed immediately upon arrival in an effort to suppress further violence. As officers enter the location or discover wounded persons in and around the location, they will provide their exact locations to OEMC.

Figure 3. Excerpt from Chicago Police Department's Active Shooter Incident Plan[48]

Unlike the complex business SOP example, the police procedures do not recognize or allow for complexity in the scenario. Instead, this example assumes that active shooters behave in predictable ways that correspond with the anticipated event. Generally speaking, because human behavior is influenced in many ways—by emotions, environment, or morality—it may demonstrate the complex system's characteristic unpredictability. Therefore, crisis professionals should expect human beings to take unanticipated actions—nonlinear behavior that severely limits the effectiveness of a prediction-dependent SOP.

The police SOP example lists the recommended steps to achieve a specific mission objective; the overarching goal is to make contact with the active shooter to prevent further injuries. This procedure imparts effective guidance if the operational setting remains consistent with the prediction, but what happens if the scenario exhibits

[48] Source: Chicago Police Department, *Active Shooter Incident Plan* (General Order G05-06), August 16, 2008, http://directives.chicagopolice.org/lt2015/data/a7a57be2-12931f77-d3712-9333-e3f729913c74616c.html.

the unpredictability of the complex domain? The active shooter could have unanticipated accomplices or explosive devices set in the building. What if the active shooter is acting under the influence of a psychoactive drug that induces non-rational, erratic behavior? The police protocols recommend that officers initially evaluate the environment before acting, which implies a degree of flexibility. However, the SOP does not recommend that officers continue to re-assess the situation for unanticipated changes that may require them to adapt their tactics. Therefore, as opposed to the computer software example, the police crisis SOP does not account for the impact of complexity on the emergency setting.

C. A FAILURE TO EVOLVE?

Business SOPs have evolved since the simple, linear domain of Taylor's production floor to accommodate the complexity of the modern business arena. Conversely, SOPs for the crisis professional have not evolved to account for complexity in emergency scenarios. This discrepancy is not necessarily a failure to evolve as much as a failure to adapt. It may be the crisis professional's reliance on accumulated work experience that has diminished the guiding role SOPs play in emergency response. One could argue that because crisis professionals rely substantially on their work experience, SOPs do not need to address the unpredictability of a complex environment. In his book *Thinking, Fast and Slow*, psychologist Daniel Kahneman, quoting Herbert Simon, agrees that experience informs decision making in a crisis environment:

> "The situation has provided a cue; this cue has given the expert access to information stored in memory, and the information provides the answer. Intuition is nothing more and nothing less than recognition." This strong statement reduces the apparent magic of intuition to the everyday experience of memory. We marvel at the story of the firefighter who has a sudden urge to escape a burning house just before it collapses, because the firefighter knows the danger intuitively, "without knowing how he knows."[49]

The aggregate of the firefighter's everyday crisis experiences refines his decision-making acumen to an instinctive level. It is this reflexive response that enables some crisis

[49] Kahneman, *Thinking, Fast and Slow*, 236–237.

professionals to react swiftly and effectively to an unanticipated development, despite the SOP providing no relevant guidance. Kahneman also identifies the downside of intuitive decision making when instinctual choices are not informed by relevant experience. He uses the example of a stockbroker's decision to buy shares in an automotive manufacturer because his "gut feeling" suggests the company makes a good car.[50] As the broker's opinion of the car does not rely on actual automotive experience or reliable insight into the company, his decision to invest is poorly informed by this gut feeling and may lead to an unfavorable outcome.

Similar to Kahneman's uninformed stockbroker example, not every crisis professional within the HSE has enough relevant experience to intuitively manage an unpredictable emergency. A rookie police officer is just as likely to face a complex emergency as an experienced veteran. Further, not all experienced crisis professionals react optimally in a high-stress setting. For example, Federal Aviation Administration (FAA) officials applied an irrelevant hijacking SOP to the September 11 attacks—even though the event diverged rapidly from the anticipated emergency. As Hales and Pronovost claim, "Human error is inevitable—particularly under stressful conditions. It has been demonstrated that levels of cognitive function are compromised as stress and fatigue level increase, as is often the norm in certain complex, high-intensity fields of work."[51] Hales and Pronovost go on to say that as judgment and proficiency diminish in the high-stress setting, operators resort to checklists and other cognitive aids in an effort to maintain efficiency.[52] Clinging to an ineffective SOP in a complex crisis can yield tragic consequences such as the failure to realize the threat on September 11 was a terror attack, not a conventional hijacking event.

From an organizational theory perspective, Karl E. Weick et al. make a related argument for abandoning hierarchical routines when an operator detects procedural errors

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50 Ibid.

51 Brigette M. Hales and Peter J. Pronovost, "The Checklist—A Tool for Error Management and Performance Improvement," *Journal of Critical Care* 21, no. 3 (2006): 231, doi: 10.1016/j.jcrc.2006.06.002.

52 Ibid.

in complex environments.[53] When the SOP provides ineffectual guidance, the emergency intensifies. If the crisis professional does not have relevant work experience to draw upon, he may become too focused on the "cheat sheet" to recognize the evolving crisis scenario. Because the crisis SOP does not stress the impact of complexity on the environment, as demonstrated by the police SOP example, it offers limited value as a guiding paradigm in a complex emergency.

Benefits of the SOP in Modern Crises: Despite its diminished applicability in a complex environment, the SOP remains a relevant tool in the emergency response field because not every aspect of a crisis is complex. Crisis professionals must also manage events that demonstrate the characteristics of the simple or complicated Cynefin domains for which SOP guidance still applies. Additionally, the predictive aspect of the SOP model provides policy makers and emergency planners a "shopping list" for various types of crises. For example, the types of resources and personnel needed to mitigate a terror attack compared to a hurricane vary widely. Organizational theorists Kendra and Wachtendorf describe the value of SOPs as a planning tool that promotes adaptability: "Prior preparedness increases the ability to improvise. … This planning forms the basis for decision making in emergency environments, and informs decisions by anticipating possible challenges or pitfalls that could come as a consequence of improvised activities."[54] Organizations within the HSE should not abandon SOPs as a tool in crisis management as they still provide relevant guidance in certain aspects of emergency planning and response. The next chapter examines disaster dilemmas in action by analyzing case studies of three modern, complex crises: the September 11 terror attacks, Hurricane Katrina, and the Fukushima-Dai'ichi nuclear event.

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53 Karl E. Weick, Kathleen M. Sutcliffe, and David Obstfeld, "Organizing for High Reliability: Processes of Collective Mindfulness," *Crisis Management* 3 (2008): 81–123.

54 Kendra and Wachtendorf, "Creativity in Emergency Response," 127.

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III. CASE STUDIES

Modern crises often demonstrate the prediction-defiant characteristics of complexity. In a complex emergency, the standard operating procedure (SOP) contributes limited value because the actual event deviates from the expectation, which significantly reduces the relevance and effectiveness of the recommended actions. Each of the following disasters represents a crisis environment that exhibited characteristics of complexity. As such, these case studies afford the opportunity to assess SOP-driven responses in action and compare them to alternative response efforts, particularly those with an adaptive response approach. The following analysis demonstrates that SOP-driven responses were often ineffective in dealing with a complex event, but adaptive countermeasures frequently achieved success despite the less predictable crisis setting.

A. SEPTEMBER 11 TERROR ATTACKS

On the morning of September 11, 2001, 19 al Qaeda operatives boarded four commercial aircraft and seized control of the cockpits shortly after takeoff. After gaining control of the planes, the hijackers intentionally crashed them into the twin towers of the World Trade Center and the Pentagon. The operatives appear to have crashed the fourth plane in a field near Shanksville, Pennsylvania, when it became evident the passengers might regain control of the aircraft. The coordinated terror attack of September 11 was one of the most significant crises in U.S. history in terms of lives lost, economic impact, and damage to the nation's sense of security. Officials estimate that 2,977 people died at the three crash sites, and the total cost in reconstruction and related economic losses exceeded $191 billion.[55] This case study demonstrates that SOP-driven emergency planning and responses were frequently ineffective, but adaptive countermeasures employed by crisis professionals and emergent ad hoc groups often succeeded in the unpredictable crisis setting.

[55] National Consortium for the Study of Terrorism and Responses to Terrorism. "9/11, Ten Years Later"; Government Accountability Office, *Review of Studies of the Economic Impact of the September 11, 2001, Terrorist Attacks on the World Trade Center* (GAO-02-700R) (Washington, DC: Government Accountability Office, 2002).

On the morning of September 11, the initial identification and management of the crisis fell on the shoulders of the Federal Aviation Administration (FAA) and the North American Aerospace Defense Command (NORAD). From the initial detection of a problem with American Airlines Flight 11, the 9/11 Commission states that crisis professionals were inhibited by their adherence to SOPs:

> The protocols in place on 9/11 for the FAA and NORAD to respond to a hijacking presumed that the hijacked aircraft would be readily identifiable and would not attempt to disappear; there would be time to address the problem through the appropriate FAA and NORAD chains of command; and the hijacking would take the traditional form: that is, it would not be a suicide hijacking designed to convert the aircraft into a guided missile.[56]

FAA officers applied the agency hijacking SOP to the unfolding crisis even after the hijackers' behavior deviated from expected behavior. The responding FAA officers adhered to the hijacking protocol by attempting communication with the pilots and coordinating support from NORAD. However, these efforts were ineffective as the actual crisis was a terror attack, not a hijacking. Therefore, the FAA's attempt to respond to the wrong type of crisis wasted time that could have been spent assessing the true nature of the event. This behavior is consistent with Parker and Stern's belief that SOPs can become an exploitable liability during a complex crisis.[57] The unanticipated and even patternless nature of the terrorists' behavior—consistent with the Cynefin Framework's complex domain—rendered the SOP-recommended actions irrelevant.

Incorrect assumptions about the operating environment also hindered NORAD's emergency planning and response. The agency believed the "dominant threat to be from cruise missiles" and depended on scenarios and related SOPs that assumed a hijacked plane would only originate from outside the United States.[58] Similarly, the flight attendants followed company SOPs that required them to cooperate with the hijackers, anticipating a negotiated solution through law enforcement intervention.[59] Essentially,

[56] National Commission on Terrorist Attacks, *The 9/11 Commission Report*, 18.

[57] Parker and Stern, "Blindsided," 601–630.

[58] National Commission on Terrorist Attacks, *The 9/11 Commission Report*, 17.

[59] Parker and Stern, "Blindsided," 601–630.

FAA officials, NORAD officers, and airline crews followed ineffective crisis SOPs; the adherence to those inappropriate procedures prevented timely countermeasures.

What could these agencies have done differently? If the FAA recognized that the crisis had diverged from the predicted hijacking scenario, the agency could have departed from standard procedures earlier. FAA officials could have pushed for a faster, more significant response from NORAD, hypothetically giving the responding military pilots a chance to intercept the airliners. National Operations Manager Ben Sliney eventually departed from agency SOPs when he grounded all commercial flights across the United States.[60] However, the agency implemented this decision approximately one hour after the first plane struck the World Trade Center—too late to save the other planes from capture. While the FAA's determination to ground all commercial flights demonstrates an element of adaptability, it also illustrates how the unforgiving pace of modern disasters can render innovative decisions ineffective when delayed by adherence to non-adaptive or inappropriate SOPs.

Adaptability in the September 11 Crisis Response: While SOP-driven preparations and actions often hindered crisis response efforts, many emergency responders were able to navigate the complex and chaotic domains by taking a flexible or adaptive approach. Kendra and Wachtendorf analyzed the September 11 attacks and drew a similar conclusion: "Creativity is such a significant feature of response to an extreme event that planning and training should move explicitly toward enhancing creativity and the resultant improvisation at all levels of responding organizations."[61] The FAA obtained minor success by departing from SOP guidance to communicate directly with NORAD. As the 9/11 Commission reported, "Lower-level officials improvised—for example, the FAA's Boston Center bypassed the chain of command and directly contacted NEADS [the Northeast Air Defense Sector of NORAD] after the first hijacking."[62] The way the U.S. Coast Guard (USCG) evacuated the water surrounding lower Manhattan was an even stronger example of adaptive disaster mitigation. USCG

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[60] National Commission on Terrorist Attacks, *The 9/11 Commission Report*.

[61] Kendra and Wachtendorf, "Creativity in Emergency Response," 139.

[62] National Commission on Terrorist Attacks, *9/11 Commission Report*, 38.

officers and inspectors successfully enlisted the aid of private and commercial watercraft to transport more than 500,000 citizens from the disaster area. USCG officers relied on their experience to recognize that certain regulations must be "adjusted with respect to ambient conditions and authority devolved to personnel closer to the scene for greater flexibility."[63] The success of these efforts did not derive from adherence to agency SOP; rather, it was the recognition that standard methods must yield to adaptive actions to solve an unanticipated problem.

While the New York Fire Department and other crisis professionals worked in and around the World Trade Center disaster site, emergent groups of private citizens self-organized to provide ad hoc safety, health, and security needs in the surrounding area. These semi-autonomous groups developed a loose connection with New York City's Emergency Operations Center but rendered assistance in a decentralized fashion as they identified various needs in the crisis environment. As Tierney states, "Individuals and groups continued to show an amazing amount of ingenuity in circumventing and subverting procedures in order to provide goods and services they believed were needed."[64] These emergent groups were uniquely suited to operate in the complex crisis environment on September 11 as the needs of the moment inspired improvisational solutions in the absence of SOP guidance.

The most poignant example of successful, adaptive behavior was the self-organized response from the passengers aboard United Airlines Flight 93. Armed with the knowledge that terrorists had hijacked three earlier flights and flown them into U.S. landmarks, strangers banded together to prevent the al Qaeda operatives from achieving their goal.[65] This emergent group saved an untold number of lives by prohibiting the flight from reaching its target destination. Despite the chaotic setting in the captured airliner, a group of civilians devised an effective solution to mitigate the evolving crisis, sacrificing themselves in the process. These examples demonstrate how an adaptive

[63] Kendra and Wachtendorf, "Creativity in Emergency Response," 133.

[64] Tierney, "Conceptualizing and Measuring Resilience," 5.

[65] W. David Stephenson and Eric Bonabeau, "Expecting the Unexpected: The Need for a Networked Terrorism and Disaster Response Strategy," *Homeland Security Affairs* 3, no. 1 (2007): 1–9.

approach to crisis response, either in the absence or defiance of an SOP, can succeed in the complex or chaotic environment of a modern crisis.

The SOPs on which various crisis planning and response entities relied during the September 11 events were ineffectual because they applied prediction-dependent guidance in complex or chaotic environments. By the time officials realized that the nature of the threat had significantly deviated from the initial assessment, it was too late to effectively mitigate the crisis. The day's operational successes consistently demonstrated examples of adaptive decision making. Kendra and Wachtendorf clarify this point: "While advance planning and preparedness serve as the backbone of disaster response efforts, creativity enhances the ability to adapt to the demands imposed upon individuals and organizations during crises."[66] Whether it was the USCG's departure from SOPs or an emergent group's operation in the absence of a standardized process, innovative decision making is clearly a characteristic that organizations must foster within their emergency responses. Likewise, the SOP is of limited value in the response to a complex crisis because it lacks the flexibility to adapt to unanticipated and emergent behavior.

B. HURRICANE KATRINA

On August 29, 2005, at approximately 6:00 a.m., category-three Hurricane Katrina struck the New Orleans metropolitan area. By the second day of the Katrina event, the levee system had partially collapsed, flooding 80 percent of New Orleans.[67] The Federal Emergency Management Agency (FEMA) describes Hurricane Katrina as the most catastrophic natural disaster in U.S. history; the National Oceanic and Atmospheric Administration estimates that 1,833 people died, and the total damage was approximately $108 billion as a result of the storm.[68] While the storm impacted 17 U.S. states to varying degrees, the vast majority of the deaths and property damage took place in Louisiana; this case study focuses on the preparation and crisis response in New

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[66] Kendra and Wachtendorf, "Creativity in Emergency Response," 121.

[67] U.S. House of Representatives, *A Failure of Initiative*.

[68] Kim Ann Zimmermann, "Hurricane Katrina: Facts, Damage & Aftermath," Live Science, August 27, 2015, http://www.livescience.com/22522-hurricane-katrina-facts.html.

Orleans. Analysis of the Katrina event further validates the argument that the application of SOPs is of limited value in mitigating a complex or chaotic crisis, yet adaptable responses often succeed.

The U.S. government was not surprised by the Hurricane Katrina disaster; officials had been expecting a hurricane crisis in the Gulf region for several years. In 2001, FEMA asserted that a major hurricane disaster in New Orleans was one of the three most likely natural crises facing the United States in the coming 30 years.[69] The actual arrival of the storm did not catch the government unprepared either; FEMA had staged resources just outside the impact zone and was at least nominally ready to respond. The initial stages of the emergency response were reasonably successful: more than 80 percent of New Orleanians were evacuated before the storm made landfall.[70] The successful relocation of area residents was an improvement over the New Orleans performance in 2004, during the less successful evacuations for Hurricane Ivan and a FEMA hurricane training scenario ("Hurricane Pam") that took place the same year.[71] President George W. Bush declared a state of emergency for Louisiana two days before Katrina made landfall, initiating the process of federal emergency assistance. In summary, the local, state, and federal government had followed SOPs and appeared to be ready for the arrival of Hurricane Katrina. However, the reality of the Katrina event was very different from the anticipated crisis, and the SOP-driven preparations proved insufficient.

What transformed the Hurricane Katrina event from a well-managed disaster response into one of the most substantial government failures in recent history? Simply stated, when Katrina struck New Orleans, a series of unanticipated problems occurred, demonstrating the prediction-defiant setting inherent in the complex and chaotic Cynefin domains. The New Orleanian crisis SOPs could not manage the unexpected deviation of the storm threat, so when the 10 to 28-foot storm surge destroyed a significant portion of

[69] Parker et al., "Preventable Catastrophe? The Hurricane Katrina Disaster Revisited," *Journal of Contingencies and Crisis Management* 17, no. 4 (2009): 206–220.

[70] Zimmermann, "Hurricane Katrina."

[71] Parker et al., "Preventable Catastrophe," 206–220.

the protective levees, emergency planners were unprepared for the sudden escalation of the crisis. Charles F. Parker et al. agree that SOPs developed to manage specific crises—in this case, the arrival of a category-three hurricane—were “completely inappropriate” and not “suitably imaginative” to manage the complex disaster brought about by the collapse of the levees.[72] The U.S. House of Representatives’ analysis levied significant blame against the failure to send federal disaster responders and supplies in a timely fashion.[73] The process of mobilizing the emergency response was one of the first SOPs to fail the victims of the Katrina crisis. The standard procedure for deploying federal relief required a multi-layered bureaucratic interplay that could not start until the Louisiana government made a formal request for assistance. After receiving the formal request, the relief application had to pass through several levels of governmental approval before finally yielding the presidential declaration of a major disaster. President Bush declared a major disaster for Louisiana at 1:45 p.m. on August 29, the day Katrina made landfall and approximately five hours after the levees began to collapse. Unlike the earlier declaration of a state of emergency, this second presidential declaration fully mobilized federal emergency relief, but the heaviest damage had already taken place without federal relief in position to render immediate assistance.[74] The crisis had moved from the marginally predictable, complex environment in the Cynefin Framework to the unpredictable chaotic domain. As in the September 11 case study, the complex and chaotic characteristics of the Katrina crisis rendered the prediction-dependent SOPs of limited value as crisis response tools.

The SOPs that FEMA employed in managing the crisis response during the Katrina event were often ill-suited to the urgency of the situation. Sobel and Leeson claim that despite significant improvements to FEMA’s methods and capabilities, the

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[72] Ibid.

[73] U.S. House of Representatives, *A Failure of Initiative*.

[74] **A Presidential Major Disaster Declaration** puts into motion long-term federal recovery programs, some of which are matched by state programs and designed to help disaster victims, businesses and public entities. **An Emergency Declaration** is more limited in scope and without the long-term federal recovery programs of a Major Disaster Declaration. Generally, federal assistance and funding are provided to meet a specific emergency need or to help prevent a major disaster from occurring. “The Federal Disaster Declaration Process and Disaster Aid Programs,” FindLaw, last updated January 13, 1998, http://corporate.findlaw.com/law-library/the-federal-disaster-declaration-process-and-disaster-aid.html.

decentralized disaster response to the attack on the World Trade Center towers was more effective than the centralized, FEMA-driven emergency response to Hurricane Katrina.[75] In one instance, several hundred firefighters volunteered to assist FEMA with disaster relief. However, FEMA's SOPs required them to attend several days of pre-deployment training on topics ranging from sexual harassment to the history of FEMA before deploying to the disaster zone. When FEMA eventually sent these experienced crisis professionals, FEMA officials tasked them with distributing informational fliers to local residents.[76] Sheriff Dennis Randle of Carroll County, Indiana, also intended to send resources and manpower to assist in the Katrina relief efforts. However, when the sheriff attempted to follow SOPs, he was so inundated with paperwork to obtain FEMA approval that he abandoned the attempt; his supplies and manpower never reached New Orleans.[77] Emergency planning in New Orleans centered on SOPs that anticipated the arrival of a category-three hurricane but an intact levee system. In response to the actual event, FEMA applied inappropriate protocols for the deployment of resources into a crisis zone flooded by collapsed levees. The agency's SOPs were too inflexible to provide useful assistance for preparing or responding when the Katrina event demonstrated the characteristic unpredictability of a complex system.

Adaptability in the Hurricane Katrina Crisis Response: As in the September 11 disaster response, responders achieved significant successes when they took action without SOP guidance or even contrary to their agency's SOPs. As a counterpoint to the example of Sheriff Randle's attempts to deploy emergency assistance, Sheriff Warren Evans of Wayne County, Michigan, ignored the SOP requiring FEMA approval and successfully arrived in New Orleans with nine trucks of supplies and 33 deputy sheriffs.[78] Likewise, the self-styled "Cajun Navy," comprising hundreds of privately-owned boats, did not seek FEMA permission to provide assistance and managed to rescue

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[75] Russell S. Sobel and Peter T. Leeson, "Government's Response to Hurricane Katrina: A Public Choice Analysis," *Public Choice* 127, no. 1–2 (2006): 55–73.

[76] USA Today, "Firefighters stuck in Ga. awaiting orders," Greg Bluestein, Associated Press, September 7, 2005.

[77] Sobel and Leeson, "Government's Response to Hurricane Katrina," 55–73.

[78] Ibid.

approximately 4,000 survivors in the New Orleans area. The owners of the Acadian Ambulance Service employed their ambulances and helicopters to evacuate more than 7,000 survivors.[79] Dr. Gregory Henderson also acted without government permission to enlist the assistance of several New Orleans police officers to raid abandoned pharmacies for medication and supplies, with which he furnished ad hoc medical assistance in downtown New Orleans.[80] Like the self-organizing groups that successfully provided assistance in and around the World Trade Center, the people of New Orleans benefited from the self-organizing, emergent crisis response of private citizens.

Both the USCG and a Vancouver search-and-rescue team began helicopter rescue operations before receiving approval from FEMA to render assistance. USCG efforts were so effective during the crisis event that the Bush administration placed USCG Vice Admiral Thad Allen in charge of the entire Hurricane Katrina relief effort after asking FEMA Director Michael Brown to step down.[81] The USCG's motto is *Semper Paratus*, "Always Ready," and its organizational response to both the September 11 and Katrina mega-crises reflect a posture of flexibility in the face of the unexpected.

Analysts Charles F. Parker et al. acknowledge that Katrina was an extraordinary crisis, but the ineffective disaster response was a normal and, therefore, repeatable failure of the nation's capacity to respond to a complex disaster.[82] The U.S. House of Representatives' analysis arrived at a similar conclusion, that the major deficiency in the Hurricane Katrina response and possibly with the philosophy of U.S. emergency management in general was a "failure of agility. Response plans at all levels of government lacked flexibility and adaptability."[83] The inadequate response during the Katrina event was not a miscarriage of preparation but a failure of the procedural philosophy behind the emergency plan. The complex and chaotic aspects of Hurricane

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79 Stephenson and Bonabeau, "Expecting the Unexpected," 1–9.

80 U.S. House of Representatives, *A Failure of Initiative*.

81 Sobel and Leeson, "Government's Response to Hurricane Katrina," 55–73.

82 Parker et al., "Preventable Catastrophe," 206–220.

83 U.S. House of Representatives, *A Failure of Initiative*, 1.

Katrina further illuminate the contrasting value of ineffective SOPs against successful adaptive responses when managing the unexpected.

C. TOHOKU EARTHQUAKE/TSUNAMI AND FUKUSHIMA-DAI'ICHI MELTDOWN

On March 11, 2011, at 2:46 p.m. local time, the magnitude 9.0 Tohoku earthquake struck in the Pacific Ocean, approximately 45 miles east of Japan.[84] Tohoku was one of the five strongest earthquakes in recorded history, generating tsunamis that began to hit the Japanese coast within 20 minutes.[85] In addition to the significant damage to Japan's coastal population, infrastructure, and assets, the earthquake and tsunami waves crippled the Fukushima-Dai'ichi nuclear power plant. Damage to the nuclear plant ultimately led to a *Level 7* nuclear incident, the gravest category on the International Nuclear and Radiological Event Scale.[86] Officials estimate that the storm caused the deaths of 15,891 people, the majority of whom drowned in tsunami waves that reached heights of 128 feet, and approximately $300 billion in damages. The ruined nuclear power plant continues to leak irradiated water into the Pacific Ocean.[87] The following analysis of the Tohoku event and consequent meltdown at the Fukushima-Dai'ichi nuclear facility further substantiates the arguments that SOPs are of limited value in mitigating a complex or chaotic emergency and that crisis responders must employ adaptable measures to succeed.

The first tsunami wave struck the Japanese coastline just 20 minutes after the earthquake, and massive waves continued to crash along a 2,000-km stretch of Japan's Pacific coast for several hours. Ultimately, the tsunami flooded a 400 km^2 area and penetrated more than 5 km inland. The Japanese government had previously determined that a magnitude 7.4 earthquake was 99 percent likely to strike Japan and had taken

84 Becky Oskin, "Japan Earthquake & Tsunami of 2011: Facts and Information," http://www. Livescience.com/39110-japan-2011-earthquake-tsunami-facts.html (2013).

85 Andrew Karam, "What Went Wrong: Fukushima Nuclear Disaster," *Popular Mechanics*, April 4, 2011.

86 Krista Mahr, "What Does Fukushima's Level 7 Status Mean?," *Time.com*, April 11, 2011.

87 Becky Oskin, "Japan Earthquake & Tsunami of 2011: Facts and Information," Live Science, May 7, 2015, http://www.livescience.com/39110-japan-2011-earthquake-tsunami-facts.html.

precautions specific to this prediction. To protect the Japanese coastline, the government had installed early warning systems, offshore and onshore tsunami barriers, and vertical evacuation structures. Additionally, the population engaged in periodic evacuation training exercises.[88] Unfortunately, these countermeasures were simply insufficient to mitigate the full impact of a 9.0 earthquake and the resulting tsunami; the wave surge washed away barriers and destroyed evacuation structures. Research scientists Okada Norio et al. summarize the disaster: "The tsunami triggered by the earthquake critically overwhelmed the coping capacity of the stricken areas. Preparedness is based on expectation and prediction, which had not taken into account the extreme situation that actually unfolded."[89] The evolution of this crisis into a catastrophic threat defied the projections of Japan's emergency planning and introduced significant elements of complexity into the disaster event. Japanese tsunami preparedness was driven by SOPs that predicted a smaller storm and did not encourage the flexibility required to adjust the crisis response when the actual event deviated from the projection.

1. Fukushima-Dai'ichi Nuclear Incident

Evolving from the Tohoku earthquake, a very different type of crisis took place at the Fukushima-Dai'ichi nuclear power plant owned and operated by Tokyo Electric Power Company (TEPCO). When the Tohoku earthquake first struck, the TEPCO site operators oversaw the implementation of SOPs for the immediate emergency shutdown of the reactors. Fortunately, three of the six reactors at Fukushima-Dai'ichi were offline for maintenance.[90] An emergency shutdown requires inserting control rods into the reactor core to halt fission, the principal energy-producing reaction that yields nuclear power.[91] Reactors continue to produce enormous heat after a shutdown and require cooling pumps to constantly circulate water to keep the nuclear fuel from melting through

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[88] Mori et al., "Survey of 2011 Tohoku Earthquake Tsunami."

[89] Norio et al., "The 2011 Eastern Japan Great Earthquake Disaster," 40.

[90] Andrew Karam, "What Went Wrong: Fukushima Nuclear Disaster," *Popular Mechanics*, April 4, 2011.

[91] "Reactor, Nuclear," U.S. Nuclear Regulatory Commission, last updated July 23, 2015, https://www.nrc.gov/reading-rm/basic-ref/glossary/reactor-nuclear.html.

the containment structures.[92] In the Fukushima prefecture, damage from the earthquake shut down the area's electrical grid, disabling the primary power source for the plant. However, the nuclear facility's emergency SOP had anticipated the possible loss of power, and backup generators immediately engaged to run the pumps circulating coolant water to the reactors.[93] At this point, onsite emergency responders followed the plant's crisis SOP and obtained successful mitigation results because the prediction was consistent with the actual event.

However, within an hour of the earthquake, the first of two 40-foot tsunami waves surged over the Fukushima-Dai'ichi plant's 30-foot sea wall, severely damaging the coolant circulation pumps and ruining the emergency generators powering them. Power for the entire plant switched over to backup batteries, which were inadequate and died within a few hours. TEPCO had a final backup power source built into its SOPs—power supply trucks outfitted with high-voltage dynamos. Unfortunately, by the time TEPCO decided to send the trucks from TEPCO headquarters 250 km from the Fukushima-Dai'ichi facility, the roads were impassable from earthquake damage and evacuation traffic.[94] When the backup batteries expired, the Fukushima-Dai'ichi plant experienced a *site blackout*, which is the nuclear power industry's worst-case scenario because it threatens a complete nuclear meltdown.[95] This event was so thoroughly unimaginable that the facility SOPs did not provide a process to mitigate it.[96] Site operators found themselves in a situation well outside their relevant work experience, stripped of any useful technology, and clinging to an SOP that no longer imparted useful guidance. As one TEPCO employee described the event, "We had undergone extensive training but none of that was applicable. It was as if we had had our legs and arms cut off and were

[92] Ibid.

[93] Karam, "What Went Wrong."

[94] Strickland, "24 Hours at Fukushima."

[95] *Nuclear Meltdown:* a puddle of molten nuclear fuel melts through the primary steel containment vessel and through subsequent barriers meant to contain the nuclear material, releasing massive quantities of radioactivity into the environment. John Matson, "What Happens During a Nuclear Meltdown?," *Scientific American*, March 15, 2011.

[96] Robert J. Geller, Woody Epstein, and Johannis Noggerath, "Fukushima—Two Years Later," *Seismological Research Letters* 84, no. 1 (2013): 1–3.

just sitting there looking at the data that was available."[97] The unanticipated impact of the tsunami waves caused interdependent systems within the nuclear power plant to collapse in a cascading effect, one system failure leading to another and another. These unexpected influences on the system were consistent with the Cynefin Framework's complex domain. As previously illustrated in the September 11 and Hurricane Katrina case studies, the evolution of a crisis into the complex domain is a circumstance in which SOPs can only provide limited assistance, as the actual event has deviated from the predicted emergency.

To further confuse the situation, Japan's Nuclear Reactor Regulation Law did not have a clear procedure to identify which government agency was responsible for making decisions in the nuclear crisis. The Japanese Prime Minister ordered the evacuation of the area surrounding Fukushima-Dai'ichi, issued a declaration of a nuclear emergency, and established a nuclear emergency response headquarters.[98] However, it appears that the government left the majority of the actual crisis response to the TEPCO employees at the facility. Okada Norio et al. describe the situation: "Coordination between the government (emergency response headquarters), the Tokyo Electric Power Company, and the nuclear and industrial safety agency were not sufficiently organized. Information was not simultaneously shared right after the disaster, which delayed efficient decision making."[99] Communication among these agencies was disjointed, which produced ineffective recommendations for SOP-derived actions. By the evening of March 11, the cascading failures caused by the site blackout induced a meltdown in Reactor 1. Subsequent efforts to mitigate the disaster over the next several days failed to prevent partial meltdowns in Reactors 2 and 3 as well as gas explosions that devastated several of the containment buildings, leaking radioactive material into the atmosphere.[100] The unanticipated site blackout, the nuclear meltdowns, and the complete lack of relevant

97 Tokyo Electric Power Company, *Fukushima Nuclear Accidents Investigation Report* (Appendix-2) (Tokyo: Tokyo Electric Company, 2012), 170.

98 Masahiko Aoki and Geoffrey Rothwell, "A Comparative Institutional Analysis of the Fukushima Nuclear Disaster: Lessons and Policy Implications," *Energy Policy* 53 (2013): 240–247.

99 Norio et al., "The 2011 Eastern Japan Great Earthquake Disaster," 40.

100 Strickland, "24 Hours at Fukushima."

SOP guidance intensified the crisis, demonstrating characteristics consistent with the Cynefin Framework's chaotic domain, a turbulent, patternless environment.

2. Adaptability in the Fukushima-Dai'ichi Crisis Response

When the TEPCO site operators faced a site blackout scenario and an increasingly inadequate SOP, they were forced to adapt to the crisis. Employees harvested batteries from cars in the plant's parking lot, studied wiring diagrams, and were able to restore power to the main control room's instrument panels. With this partial restoration of power, employees could assess the status of the reactors and make decisions informed by current information.[101] On the second day of the event, the facility manager ignored an order from TEPCO headquarters to stop injecting seawater to cool Reactor 1 as saltwater is typically forbidden for use as a reactor coolant. Experts believe that the plant manager's choice to go "off script," defying both SOPs and offsite instructions, prevented a more significant nuclear meltdown.[102] Plant personnel faced with ruined circulation pumps innovated a method to cool the overheating reactors by employing onsite fire engines to inject water directly into the cooling system.[103] Finally, when urgent efforts to cool the superheated reactors with water yielded an enormous build-up of steam, hydrogen, and other gases, site operators applied an air compressor to blast open a locked valve to release the pressure.[104] While the facility suffered irreparable damage, the employees' innovative efforts limited the impact of the nuclear incident. Their demonstrated adaptability yielded successful, if limited, crisis mitigation despite the complex and chaotic aspects of the disaster event.

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[101] Ibid.

[102] Aoki and Rothwell, "Fukushima Nuclear Disaster."

[103] Strickland, "Hours at Fukushima."

[104] Ibid.

D. CASE STUDY CONCLUSIONS

Emergency SOPs provided ineffective and often inadequate guidance to prepare for the complex crises of the September 11 attacks, Hurricane Katrina, and the Fukushima-Dai'ichi nuclear event. When the actual disasters deviated from the predicted events, emergency responders found themselves adhering to irrelevant procedures. The examination of successful governmental responses during these mega-crises identifies conscious decisions to depart from SOPs and embrace innovative solutions. In the instances of self-organized, emergent crisis responses from private industry and citizens, the absence of prescribed actions yielded adaptable behavior tailored to the needs of the specific emergency.

The case studies demonstrated that SOPs fail to provide useful guidance for complex disasters because they lack the adaptability needed to manage unexpected variants in the crisis environment. However, the emergency response field is unlikely to abandon the practice of employing SOPs to guide emergency response. Therefore, a direct and practical solution to this dilemma is to integrate adaptive qualities into the SOP model, enabling it to better manage the variability of complex crises. The next chapter proposes a method to build adaptability into the checklist structure of pre-existing crisis SOPs.

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IV. DEVELOPING THE ADAPTIVE SOP RESPONSE

The only true wisdom is to know that you know nothing.

—Socrates, 5th century, B.C.

Don't assume a damn thing.

—Mayor Rudy Giuliani, 2002

In their current form, standard operating procedures (SOPs) are too rigid to provide effective direction when a crisis exhibits complex characteristics. A reliance on rote, checklist guidance in lieu of innovative or adaptive solutions has the potential to hamper emergency response when the disaster reality diverges from the disaster projection. Bolton and Stolcis argue that standardized procedures are not effective "when 'wicked' problems alter the decision-making environment because there is little time to react to changing conditions. These problems are wicked because they are poorly formulated and fall outside normal boundaries of decision-making."[105] The onset of spontaneous problems within a crisis is the hallmark of the prediction-defiant complex environment; in the jargon of complexity theory, a wicked problem is the manifestation of an emergent event during a disaster. Modern crisis SOPs lack the adaptability required to impart effective guidance for the emergent conditions found in a complex disaster.

The previous chapters have identified the core deficiencies of the traditional SOP model in managing complex crises and contrasted them against the adaptive behaviors that led to success in the same environments. By understanding the nature of SOP failures and the comparative successes of adaptive crisis response, Homeland Security Enterprise (HSE) policy makers can renovate the traditional SOP model to effectively address its limitations in complex environments. This chapter presents two proposals to modify the SOP-driven approach to emergency response, prompting the identification of unanticipated elements within the crisis environment and promoting adaptive action.

[105] Bolton and Stolcis, "Overcoming Failure," 3.

A. CRISIS RESPONSE AS A COMPLEX ADAPTIVE SYSTEM

The fundamental weakness in SOP guidance for complex crises is the application of static doctrine for managing highly variable emergencies. When Uhl-Bien, Marion, and McKelvey analyze the behavior of a complex adaptive system (CAS) in their work, "Complexity Leadership Theory," they define a relevant distinction between administrative and adaptive leadership: "Administrative leadership refers to the actions of individuals and groups in formal managerial roles who plan and coordinate activities to accomplish organizationally-prescribed outcomes in an efficient and effective manner."[106] The traditional SOP model is an example of administrative leadership—a pre-staged plan of action supplied by leadership to accomplish a set of predicted goals within a predicted environment. Uhl-Bien, Marion, and McKelvey argue that administrative leadership fails to provide the necessary adaptability to manage environmental changes. They claim that complex environments require adaptive leadership, which is "an informal emergent dynamic that occurs among interactive agents … and is not an act of authority."[107] When applied to a complex crisis environment, the analysis tendered by Uhl-Bien, Marion, and McKelvey suggests that emergency response must function as a CAS, following a course dictated by a dynamic interaction with the disaster environment rather than by bureaucratic protocols prescribed by a remote authority.

The application of CAS principles is particularly relevant to emergency response in a complex environment. Bruce MacLannen states, "Many complex systems are adaptive in that they respond to their environments and alter their behavior in such a way that they can maintain or improve their function, or so that they can 'survive' (that is, continue to persist as organized systems)."[108] Additionally, Holland describes a CAS as having the ability to learn about the environment at a local level, thereby allowing adaptive aggregate behavior to emerge.[109] This insight into the structure and purpose of a

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106 Uhl-Bien, Marion, and McKelvey, "Complexity Leadership Theory," 305.

107 Ibid., 305.

108 MacLennan, "Evolutionary Psychology," 172.

109 J. H. Holland, "Complex Adaptive Systems," *Daedalus* 121, no. 2 (Winter 1992): 17–30.

CAS sheds direct light on the necessary evolution of the modern crisis SOP. Emergency responders must behave as interacting agents within a CAS, adapting to the spontaneity of the complex setting to effectively mitigate the emergency and—literally—survive the crisis environment.

Modern emergency response must evolve away from reliance on static, pre-arranged instructions and embrace the paradigm of a CAS. Louise Comfort et al. describe the essential nature of a CAS as "the spontaneous reallocation of energy and action to achieve a collective goal in a changing environment … [wherein] organizations adapt their performance to meet unexpected needs."[110] The ability to engage in flexible, dynamic responses to unexpected deviations ensures the effectiveness of the interacting agents within a complex system, a point of the highest possible relevance in navigating the wicked problems of a complex disaster event. Therefore, an adaptable SOP must promote the concepts of adaptive leadership and cultivate the behavior of a CAS among emergency responders. Proposals for an adaptive redesign of the crisis SOP model must be more than concrete sets of instructions; they must serve as decision support systems that guide crisis professionals to interact with the disaster setting like agents within a CAS.

B. THE SOCRATIC METHOD

The Socratic method of inquiry, sometimes referred to as the *dialectic method*, is a cognitive process intended to stimulate critical thinking and comprehension through a dialogue of questions and answers. Complexity scholars Richard Paul and Linda Elder describe the basis for the Socratic method as an educational platform that stimulates high-level comprehension rather than simple rote learning: "Recognize that all thoughts presuppose an information base. Assume that you do not fully understand the thought until you understand the background information that supports or informs it."[111] Educational researchers emphasize that this technique challenges potentially erroneous

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110 Comfort et al., "Complex Systems in Crisis," 146.

111 Elder and Paul, "Socratic Questioning," 298.

assumptions and prevents a bias toward any single, correct answer.[112] The Socratic method emphasizes that the initial information or analysis upon which an individual relies is neither stable nor reliable in the long-run; an individual achieves genuine comprehension by challenging initial conceptions with new ideas and empirical observations.

The principal concept of the Socratic method is that a student develops a more complete comprehension of the topic of instruction by asking and answering questions—aptly named *Socratic questioning*—that are structured to expand the understanding of a topic. Education professors Ya-Ting Yang, Timothy Newby, and Robert Bill contend that this method promotes comprehension rather than memorization, which ultimately yields a more thorough understanding of the subject. "Instead of providing direct answers, the Socratic questioning approach stimulates students' minds by continually probing into the subject with thought-stimulating questions."[113] This process depends on challenging initial presumptions through the acquisition of additional information on the topic. The Socratic method pursues the achievement of comprehension based on empirical knowledge, facilitating conclusions derived from an active, cognitive challenge and re-assessment of the subject matter. Paul describes the taxonomy of the Socratic method of inquiry in Table 1.

112 Whiteley, "Using the Socratic Method."

113 Ya-Ting C. Yang, Timothy J. Newby, and Robert L. Bill, "Using Socratic Questioning to Promote Critical Thinking Skills through Asynchronous Discussion Forums in Distance Learning Environments," *The American Journal of Distance Education* 19, no. 3 (2005): 164, doi: 10.1207/s15389286ajde1903_4.

Table 1. A Taxonomy of Socratic Questions[114]

	Types of Questions	Sample Questions
1	**Clarification**	Could you put that another way?
2	**Probing Assumptions**	What are you assuming?
3	**Probing Reasons and Evidence**	Why do you think that is true?
4	**Viewpoint and Perspectives**	What effect would that have?
5	**Probing Implications and Consequences**	Why is this issue important?
6	**Questions about Questions**	What does that mean?

The Socratic method does not provide students with absolute answers; in fact, a professor using the Socratic method promotes the belief that there are no absolute truths. Whiteley states, "The Socratic approach is used to get one to re-examine what they believe; it is not an approach used to present absolute information."[115] Socratic instructors guide students to reach their own conclusions through the dialectic process, which intentionally extinguishes any pre-existing assumptions.[116] Therefore, instructors using this approach do not directly impart knowledge to their students; they guide students' cognitive efforts to keep their lines of questioning oriented toward the precepts of the Socratic method. Scholars refer to this educational practice as *scaffolding*, a term appropriately reminiscent of the structures that support and contain a construction work in progress. The instructor guides the students' efforts in a manner that keeps the learning process consistent with the Socratic tradition.

While many contemporary educators promote the Socratic method to teach the art of critical thinking, this approach has also garnered its share of criticism as an academic

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[114] A taxonomy of Socratic questions is presented in Richard Paul, *Critical Thinking: How to Prepare Students for a Rapidly Changing World* (Tomales, CA: Foundation for Critical Thinking, 1995).

[115] Whiteley, "Using the Socratic Method," 66.

[116] Ibid.

technique. A prevailing argument against the Socratic approach to education is that the dialectic method puts timid or apprehensive students at a disadvantage as they are less capable of participating in an analytic debate and, therefore, less likely to benefit from the Socratic process.[117] The ambiguous nature of Socratic questioning can also represent a challenge in applying the method in either the classroom or practical environments. Socratic practitioners learn to interrogate their environment to achieve genuine comprehension. However, they must determine which questions are useful, as the choice to pursue an unproductive inquiry wastes time and effort.[118] In addition to arguments against its use in the classroom, critics also believe that the Socratic method promotes a *groupthink* atmosphere in which participants gravitate toward homogenized opinions and reject contrarian views. Ramon Aldag and Sally Fuller contend that the groupthink environment tends to produce flawed decisions in the absence of opposing arguments.[119] The Socratic method is a controversial process; practitioners require a genuine understanding of its methodology and purpose to successfully utilize its cognitive benefits.

The employment of Socratic methodology extends beyond promoting pedagogical critical thinking. Its practices have a direct application to professions engaged in time-sensitive problem solving. Irving Sigel contends that Socratic questioning improves an individual's capacity for higher reasoning because the process triggers creative and abstract thinking.[120] James Overholser makes a similar argument, suggesting "the content of most Socratic questions is designed to foster independent, rational problem solving."[121] The principles of a Socratic methodology engender effective and thorough assessments of an issue as well as a practical means to assess potential solutions through

[117] Orin Kerr, "The Decline of the Socratic Method at Harvard," *Nebraska Law Review* 78 (1999): 113–127.

[118] Robert C. Oh, "The Socratic Method in Medicine—The Labor of Delivering Medical Truths," *Family Medicine-Kansas City* 37, no. 8 (2005).

[119] Ramon Aldag and Sally R. Fuller, "Beyond Fiasco: A Reappraisal of the Groupthink Phenomenon and a New Model of Group Decision Processes," *Psychological Bulletin* 113, no. 3 (1993).

[120] I. E. Sigel, "On Becoming a Thinker: A Psychoeducational Model," *Educational Psychologist* 14 (1979) 70–78.

[121] James C. Overholser, "Elements of The Socratic Method: I. Systematic Questioning," *Psychotherapy* 30, 1 (1993): 69.

the dialectic process. The core Socratic principle of disavowing assumptions and re-assessing the subject matter against new ideas and observations is particularly relevant in dealing with complex environments. Paul and Elder contend, “Deep questions drive our thought underneath the surface of things, forcing us to deal with complexity. Questions of information force us to look at our sources of information as well as at the quality of our information. … Questions of assumption force us to examine what we are taking for granted.”[122] Recalling the case studies of evolving, prediction-defiant complex crises, the Socratic method represents a uniquely suitable foundation to mitigate complexity in the modern disaster environment.

C. POLICY RECOMMENDATIONS: ADAPTIVE DESIGN PROPOSALS

The Socratic method is a particularly relevant philosophy for emergency response in a complex crisis. Its emphasis on challenging assumptions and evaluating—and then re-evaluating—the problem prepares emergency responders to expect an evolving scenario. The Socratic philosophy strictly opposes dependence on assumptions, which can be the basis for ineffective decision-making in the crisis environment. The crisis case studies in Chapter III illustrated numerous occasions when response efforts weakened or failed due to erroneous or irrelevant expectations.

The Socratic method promotes an active search for knowledge as a means to achieving thorough comprehension. As such, it is an ideal foundation to develop a dynamic process for comprehending and acting within a variable environment. The complex crisis defies prediction, so the crisis responder who relies on assumptions is less likely to succeed. Patrick Lagadec further clarifies this point: “The cardinal principle is this: not to strive to foresee the unforeseeable but to train ourselves to cope with it. Not to clarify, map and plan for every single surprise, but to train to be surprised.”[123] Therefore, the crisis responder who expects an evolving scenario and regularly questions his

[122] Elder and Paul, “Socratic Questioning,” 297.

[123] Patrick Lagadec, “A New Cosmology of Risks and Crises: Time for a Radical Shift in Paradigm and Practice,” *Review of Policy Research* 26, no. 4 (2009): 484, doi: 10.1111/j.1541-1338.2009.00396.x.

comprehension of the threat enhances his potential to mitigate undesirable outcomes from a complex event.

As a foundation for adaptive crisis SOPs, Table 2 presents the aforementioned Socratic questions, modified for application in the emergency response field.

Table 2. A Taxonomy of Socratic Questions for the Crisis Environment[124]

	Types of Questions	**Sample Questions**
1	**Clarification**	How does new evidence or a new event relate to the crisis situation and response plan?
2	**Probing Assumptions**	How does new information change the initial expectations about the crisis?
3	**Probing Reasons and Evidence**	How will new information or a new event impact the crisis environment?
4	**Viewpoint and Perspectives**	How does the new evidence or event impact the response plan?
5	**Probing Implications and Consequences**	How should new information or a new event change the response plan?
6	**Questions about Questions**	How does this new information actually impact the crisis situation?

These are the questions that an adaptive crisis responder should ask of the environment. This is the Socratic scaffolding that should demarcate his approach to a complex disaster environment. By applying the Socratic method to a complex disaster, emergency responders can ask questions to avoid erroneous, even lethal, assumptions and identify opportunities to adapt and innovate in their response actions.

As explained in the analysis of complex versus complicated systems, the twenty-first century is a changed environment, and its hyper-connected nature has irrevocably diminished the value of prediction-dependent SOP guidance in a crisis. However, the use of SOPs appears to be an indelible component of government procedures, even in

124 Adapted from Paul, *Critical Thinking*.

complex scenarios when their contribution is suspect. Lagadec suggests a practical way forward in facing this dilemma: "When the world mutates, the ruling theories and best practices become outmoded, and even lethal pitfalls. …Our cherished models, those that have been so meticulously built in the last decades, are increasingly less relevant as new horizons of risks and crises unfold."[125] The HSE is unlikely to abandon its reliance on SOP guidance, so its standardized process must evolve to manage complex disasters.

1. Adaptive Design Proposal #1—Adaptability Prompts

Can the standardized process that Frederick Winslow Taylor used to preempt deliberation and creativity on the assembly line evolve to promote critical thinking? How does the traditional, static SOP model become adaptive? The first design proposal answers these questions by recommending the integration of *adaptability prompts* into the SOP model. These prompts are instructional steps added into an existing SOP checklist to guide responding officers in a complex scenario. This adaptive design proposal helps the emergency responder quickly identify unanticipated changes in the scenario and evaluate how these changes should modify the crisis response. Lagadec and Topper argue that crisis responders must learn to expect surprises in complex emergency scenarios and plan to revise response actions accordingly. They further contend that the paradigm shift from traditional, rote crisis response to dynamic emergency management requires modifying institutional design.[126] Lagadec clarifies the need for changing the methodology behind modern crisis response: "When the pace, the scope and the nature of the terrain thus depart so abruptly from accepted blueprints, our visions, our initiatives and our tools rapidly fall apart. We must rebuild them, and do so urgently."[127] Adaptability prompts are necessary improvements to one of the traditional tools for crisis response—a calculated upgrade to urge awareness of complexity in the field and to promote adaptable behavior.

[125] Patrick Lagadec, "A New Cosmology," 474.

[126] Lagadec and Topper, "How Crises Model the Modern World."

[127] Lagadec, "A New Cosmology," 480.

Adaptability prompts are based on Socratic questioning and intended to stimulate critical thinking. The Socratic method opposes absolute answers and promotes an evaluative (and re-evaluative) process for digesting a problem. The adaptive SOP design relies on those same principles to encourage crisis responders to regularly evaluate the crisis environment and adapt their behavior appropriately to the needs of the moment. By incorporating these concepts into the decision process, emergency responders can more effectively manage evolving emergencies.

By modifying existing crisis SOPs with the adaptability prompt concept, the guidance provided to emergency responders promotes an expectation that the crisis scenario will change and their actions in the field should adapt, matching emergent behavior to the emergent environment. To illustrate the proposal, Figure 4 presents the police SOP for active shooters introduced in Chapter II, modified to incorporate adaptability prompts, which are highlighted in yellow.

Upon being assigned to an Active Shooter Incident, the first sworn Department member (regardless of rank) arriving on the scene will:

1. Verify that there is a bona fide Active Shooter Incident taking place.
2. Request assistance through the Office of Emergency Management and Communications (OEMC).
3. Determine the location of the incident, suspect description and actions, and type(s) of weapon(s) used and immediately communicate that information to responding units.
   a. This information establishes the **baseline expectations** for the threat scenario.
   b. Anticipate these expectations will change.
4. Immediately upon the arrival of the first assist units, form a contact strike team.
   a. Before entry, **re-evaluate baseline expectations** about the threat scenario:
      i. Has new information become available since the initial baseline expectations?
      ii. Could there be additional threats present (e.g., unidentified violators on site or explosive placements)?
      iii. How should other threats or additional information affect entry tactics?
   b. Modify operational plans to incorporate any scenario change.
5. Enter the location of the incident, as a team, and begin an active search to locate, isolate, secure, and neutralize the assailant(s).
   a. Upon entering the scene, **continue to re-evaluate baseline expectations** about the threat scenario (as described in step 4a) **and modify operational plans** to incorporate any scenario change.

NOTE: These duties need to be completed immediately upon arrival in an effort to suppress further violence. As officers enter the location or discover wounded persons in and around the location, they will provide their exact locations to OEMC.

Figure 4. Active Shooter SOP with Adaptability Prompts[128]

The incorporation of adaptability prompts into the SOP structure may help crisis professionals more effectively manage complex emergencies. The SOP modifications make the expectation of change a core theme in every emergency response. Even more

[128] Adapted from Chicago Police Department, *Active Shooter Incident Plan*.

importantly, the prompts compel the emergency responder to adjust his operational plan to counter the developments in the scenario. The inclusion of adaptability prompts may help integrate complexity awareness and adaptive action into the emergency response field, which would re-shape the traditional SOP model into a more effective tool for managing complex crises.

2. Adaptive Design Proposal #2—The Crisis Co-pilot

An essential element for the success of an adaptive SOP is the emergency responder's ability to think quickly and critically as well as act effectively within a complex scenario. The crisis professional must challenge assumptions and identify deviations in the emergency event before taking action. Therefore, it is critical that excessive deliberation or "paralysis by analysis" does not inhibit or delay timely action in the crisis environment.[129] The obligatory component of critical thinking in this adaptive design proposal should never hinder emergency response; it should only enhance and refine the emergency responder's efforts.

As previously mentioned, teachers of the Socratic method provide scaffolding for their students' cognitive processes. Whiteley clarifies the purpose of scaffolding: "As the student begins to swerve off course or hits a brick wall, the role of the instructor is to direct the student in the right direction, but without providing the answers."[130] Crisis professionals would benefit from similar assistance to keep their cognitive process consistent with the Socratic method while progressing toward timely and adaptive response actions during a complex emergency.

Lagadec and Topper also recommend the provision of cognitive assistance during an emergency. They developed the concept of a crisis assistance group to aid in the detection of unexpected elements within a complex crisis. They describe this support unit as a *rapid reflection force* whose purpose is "to help the leader to grasp and confront issues raised by unconventional situations. It does so by developing unconventional

[129] This phrase is attributed to Igor Ansoff in his 1965 work, *Corporate Strategy: An Analytic Approach to Business Policy for Growth and Expansion*, and refers to a preoccupation with the analytical process leading to a failure to act.

[130] Whiteley, "Using the Socratic Method," 68.

responses when usual toolkits and references turn out to be irrelevant, or indeed dangerous."[131] Lagadec and Topper's concept suggests that leading emergency response actions in the field while simultaneously evaluating (and re-evaluating) the crisis environment and operational plan is a task that exceeds the capacity of a single crisis professional.

Lagadec describes the emergency responder as a "crisis pilot" who navigates the unexpected to mitigate a complex disaster.[132] In deference to Lagadec's work on emergency management in complex environments, the second adaptive design proposal recommends instituting a *crisis co-pilot*. This concept synthesizes elements of the Socratic method's scaffolding as well as Lagadec and Topper's rapid reflection force to create a professional role within the emergency response field that supports a primary emergency responder—the crisis pilot—in an advisory capacity. The crisis co-pilot assists the lead emergency responder in adhering to the Socratic tenets recommended by the adaptability prompts. His primary function is to remind the lead emergency responder to (1) question expectations in the crisis scenario, (2) consider the impact of unpredicted deviations, and (3) conceive adaptive modifications to the operational plan in order to adapt to the unexpected.

To visualize the role of a crisis co-pilot, consider the hypothetical impact it could have made on September 11, 2001, when the Federal Aviation Administration (FAA) initially detected a problem with American Airlines Flight 11, the first plane hijacked during the event. The initial air traffic controller (ATC) had a number of SOP-driven duties to perform while assessing the anomalous flight, which was not an ideal moment to deliberate over potentially erroneous assumptions. In this scenario, the ATC would identify the irregular—and potentially threatening—situation to an FAA staff member trained to serve as a crisis co-pilot. The lead controller would continue to manage the requisite SOP duties while the crisis co-pilot joins the management process, observing the unfolding situation, and providing advice that prompts critical thinking and adaptive behavior.

[131] Lagadec and Topper, "How Crises Model the Modern World," 28.

[132] Patrick Lagadec, "Navigating the Unknown," *Crisis Response Journal* 2, no. 1 (2012): 21–33.

Imagine the crisis co-pilot periodically posing the questions suggested by the adaptability prompts to the principal emergency responder: Has new information become available since the initial baseline expectations? How should other threats or additional information affect tactics? In this theoretical version of the 9/11 attacks, the crisis co-pilot's advice guides the lead controller to challenge his initial assumptions and potentially recognize the unexpected nature of the attack earlier. The crisis co-pilot's role is not intended to predict the unexpected. His role is to scaffold the principal emergency responder's cognitive process within the framework of the adaptability prompts concept, avoiding myopic biases that develop from static assumptions about the crisis event and prediction-dependent SOP guidance.

The implementation of the adaptability prompts concept and the crisis co-pilot role is intended to induce critical changes in the emergency management paradigm, allowing responders to more effectively manage complex events. Both adaptive design proposals will compel crisis professionals to assess an evolving emergency and anticipate the need for adaptive countermeasures. While the implementation of either design will enhance the emergency response during a complex event, emergency responders would ideally employ them together in order to reinforce their impact on the emergency response paradigm.

D. IMPLEMENTATION METHODOLOGY FOR THE ADAPTIVE DESIGN PROPOSALS

This thesis has demonstrated that SOP guidance does not sufficiently account for the presence of complexity in the modern crisis environment. Lagadec contends, "The strategic landscape has mutated, the conventional tactics and interpretations no longer work and are even counterproductive. We must … construct new frameworks for understanding and coping with reality."[133] Leaders within the HSE need to apply the lessons taught by today's mega-crises to reform the foundations of modern emergency response. The HSE should implement policy changes that promote adaptability and innovation to mitigate complex disasters.

[133] Lagadec, "A New Cosmology," 481.

To introduce these institutional changes, policy makers must first garner organizational sponsorship for the new proposal. Governance professors Arjen Boin and Paul ’t Hart argue that policy makers should identify the “reform imperative … to build support for nonincremental reform, [and] portray crises as the result of flaws in the existing institutional order.”[134] In order to successfully change the fundamental orientation of emergency management from prediction-dependent response to analytic, innovative response, policy makers must first convince HSE leadership that previous failures in emergency response were the result of an outmoded methodology. The case studies and analysis provided in Chapter III exemplify the manner in which policy makers can demonstrate the failure of prediction-dependent SOPs and the successes of adaptive behavior in managing complex disasters. This compelling analysis implies that the failure to make these proposed policy changes risks future calamities. If HSE leaders genuinely comprehend both the conceptual value of these policy proposals as well as the implied threat of ignoring the associated analysis (in terms of avoidable future catastrophes), it seems reasonable that they would approve these adaptive design proposals.

After securing executive approval for the policy proposal, HSE policy makers need to convert the adaptive design concepts into a working reality. The adaptability prompts and the advisory role of a crisis co-pilot are uncomplicated upgrades to an HSE agency’s crisis response paradigm. However, they still require emergency responders to learn and practice the procedural changes. Emergency response agencies can introduce these new procedures into their standard, periodic re-certification training.

The general training process should begin with classroom instruction that clarifies the purpose of the adaptive SOP modifications and explains the additional steps and the function of the crisis co-pilot. After the classroom portion of the training, operators should engage in practical exercises to hone these new techniques into operational readiness. Once the operators have achieved proficiency with the adaptive modifications, there should be an opportunity to provide feedback to HSE leadership regarding the

[134] Arjen Boin and Paul ‘t Hart, “Public Leadership in Times of Crisis: Mission Impossible?” *Public Administration Review* 63, no. 5 (2003): 549, doi: 10.1111/1540-6210.00318.

effectiveness of the training techniques and the successes or challenges of the adaptive designs in the field. As it is unlikely that the first iteration of this policy will be perfect, HSE leadership should anticipate refining the training and operational process to make the adaptive design proposals successful in the field.

HSE policy makers can immediately institute an elementary form of the crisis co-pilot by assigning personnel to pose adaptability prompts during an emergency (or training) scenario. Depending on the nature of the agency, its leadership may choose to situate this role within a department that already serves a communications function such as a police radio dispatch unit. In fact, several police agencies in the United States have expanded the responsibilities of their communications personnel to incorporate a tactical component, establishing an operational link between the communications center and officers responding to an event. The advisory role of the crisis co-pilot would be a natural fit for a communications-centric police professional.

Regardless of their station in the implementing agency, personnel serving as crisis co-pilots would greatly benefit from training in the Socratic method. There are numerous advanced training opportunities available through universities, non-profit organizations, and private industry that teach Socratic techniques to foster critical thinking. For example, Johns Hopkins University's Center for Transatlantic Relations has sponsored seminars on strategies for managing complex crises.[135] In addition, Socratic Seminars International delivers professional workshops in the Socratic method. Ideally, emergency response personnel serving in the ad hoc role of crisis co-pilot would attend recurring training to enhance their ability to provide adaptive scaffolding to the crisis professionals they assist in the field.

Sociologist Edgar Morin claims, "Nothing is more difficult than modifying a cornerstone concept."[136] Bearing in mind the implied challenge in adjusting institutional procedures, the design proposals for integrating adaptability into the emergency response

[135] Erwan Lagadec, *Unconventional Crises, Unconventional Responses: Reforming Leadership in the Age of Catastrophic Crises and Hypercomplexity* (Washington, DC: Center for Transatlantic Relations, 2008).

[136] Edgar Morin, "Introduction a la Pensee Complexe [Introduction to Complex Thinking]," Éditions du Seuil, Paris, 2005, 76. (Cited by Lagadec in "Navigating the Unknown.")

paradigm are deliberately straightforward and intuitively simple. Adaptability prompts are modest adjustments to a pre-existing crisis SOP, and while the crisis co-pilot role would benefit from specialized training, emergency response agencies can institute its ad hoc advisory function with very basic instruction. In short, the adaptive designs are simple improvements to the emergency response tool box, engineered for quick and uncomplicated implementation in the field. By integrating adaptability into emergency response, the HSE prepares its professionals to effectively manage complex disasters and, in doing so, better protect their communities.

When considering a new venture like the adaptive design proposals, HSE policy makers must assess the project's potential merits. The following chapter presents the results of a computer simulation model devised to illustrate the potential benefits of employing the adaptive design proposals in a crisis environment.

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V. EVALUATING THE ADAPTIVE DESIGN PROPOSALS

When considering any new project, government agencies must attempt to accurately assess its merits. Whether deliberating over a procurement request or a law-enforcement field operation, decision makers are expected to evaluate its prospective benefits and likelihood of success before committing personnel and resources.[137] This process is challenging as it requires an estimation of a proposal's potential. The evaluator must play the role of fortuneteller to produce an analysis of future performance.

Fortunately, modern computing advancements have improved the forecasting powers of government leaders. Decision makers within the Homeland Security Enterprise (HSE) are now able to execute a proposed decision within a virtual environment, allowing various factors to interact and influence the result without risking actual government assets or personnel. David Simeone and Yehuda Kalay claim that simulations "allow [proposal] designers to evaluate … performance and, if necessary, to intervene to solve emergent usability problems, critical points and inconsistencies."[138] Simulated environments allow researchers to quantify the relevance and impact of various risk factors on the proposed project. As a decision support tool, multi-agent system (MAS) modeling is particularly useful for assessing the merits of a proposed action.

A. MULTI-AGENT SYSTEM SIMULATION AS A DECISION SUPPORT TOOL

MAS simulations are frameworks that approximate human decisions within a virtual system to identify the best means for achieving a desired outcome. Xiaoshan Pan et al. describe this scientific methodology as "an artificial environment populated with

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[137] Thomas Housel and Johnathan Mun, "A Primer on Applying Monte Carlo Simulation, Real Options Analysis, Knowledge Value Added, Forecasting, and Portfolio Optimization," Naval Postgraduate School, 2010.

[138] Davide Simeone and Yehuda E. Kalay, "An Event-Based Model to Simulate Human Behaviour in Built Environments," *Proceedings of the 30th eCAADe Conference* 1, (2012): 532.

autonomous agents, which are capable of interacting with each other."[139] The overarching purpose of the MAS framework is to simulate individual human decision processes as well as to depict emergent patterns of individuals or factors interacting within the system.[140] Individuals can apply this method of simulating and studying human behavior to any type of scenario, from the financial impact of acquiring a new vendor to the police response to an active shooter event.

By following a set of behavioral rules, computer simulations can approximate human cognitive processes. These rules identify possible choices in each moment of virtual interaction and ultimately define the nature and quality of the virtual environment. If the simulation does not accurately represent the choices appropriate to the scenario, the exercise will inaccurately represent reality. As J. Doyne Farmer and Duncan Foley state, "The major challenge lies in specifying how the agents behave and, in particular, in choosing the rules they use to make decisions. In many cases this is still done by common sense and guesswork, which is only sometimes sufficient to mimic real behaviour."[141] Susan Sanchez defines the need for randomization in the virtual environment as "a probabilistic guard against the possibility of unknown, hidden sources of bias surfacing to create problems with your data."[142] The computer simulation assigns probabilities that agents in the scenario will make specific choices and then effectively rolls a set of virtual dice to determine the outcome. By purposefully incorporating randomness into the simulation, model designers can produce statistically relevant results and a convincing imitation of reality.

The number of choices available in each possible interaction in the virtual environment defines the simulation's relative *resolution*, or the degree of its resemblance to the real world. Arnold Buss and Darryl Ahner explain that a high-resolution simulation

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[139] Xiaoshan Pan et al., "A Multi-agent Based Framework for the Simulation of Human and Social Behaviors during Emergency Evacuations," *AI & Society* 22, no. 2 (2007): 114, doi: 10.1007/s00146-007-0126-1.

[140] Ibid.

[141] J. Doyne Farmer and Duncan Foley, "The Economy Needs Agent-Based Modelling," *Nature* 460, no. 7256 (2009): 686, doi: 10.1038/460685a.

[142] Sanchez, "Work Smarter," 69.

model contains a significant number of nuanced possibilities within the virtual environment, simulating "every element and entity with many attributes … to model the dynamics and interactions to a very fine degree."[143] A high level of nuance creates a more realistic environment, but the computing power required to manage all the interconnected possibilities can quickly outpace the capacity of the computer running the simulation.[144] For this reason, decision makers frequently employ low-resolution simulation models when considering a proposed project. The low-resolution model does not incorporate the same level of detail, but users can run these simulations and analyze the results in a reasonably short period of time and still deliver information that is relevant to government decision makers.

Building an accurate simulation not only requires the identification of appropriate choices within the MAS framework but also the assignment of realistic probabilities for these options to take place. MAS simulations define the various decision probabilities based on a range of disciplines, which may include sociology, cognitive psychology, game theory, or observational data.[145] The methodology behind assigning quantitative probabilities to qualitative—sometimes illogical—decision processes is a product of social theories, observed data, and educated guesses, often described by social scientists as a mixture of science and art.[146]

B. THE HEURISTIC 9/11 SIMULATION EXPERIMENTS

There is a variety of MAS simulation model types, each one oriented to different environments, interacting agents, and logic frameworks. This thesis presents a *heuristic* MAS simulation that relies on historical data from the September 11 attacks to illustrate the potential value of the adaptive standard operating procedure (SOP) designs. Heuristic simulation models are low-resolution, virtual systems based on observed data.[147]

143 Buss and Ahner, "Dynamic Allocation of Fires and Sensors," 1358.

144 Ibid.

145 An, "Modeling Human Decisions," 25–36.

146 Ibid.

147 Ibid.

Researchers convert observational data into “logic rules,” or heuristics, which govern the decisions of interacting agents within the system.

To illustrate the potential benefit of the adaptive design proposals presented in Chapter IV, I designed and executed a heuristic MAS simulation based on the crisis response decisions made at the Federal Aviation Administration (FAA) and North American Aerospace Defense Command (NORAD) on the morning of September 11, 2001.[148] I constructed the simulation using Northrop Grumman’s *Pythagoras* simulation suite (version 2.1), an off-the-shelf virtual environment designed to test a wide variety of scenarios, from armed combat to propaganda influences on a community.[149] The logic rules governing the behavior of the virtual agents are based on empirical observations taken from official accounts of the September 11 attacks and on a professional assessment of the FAA response paradigm to aviation anomalies in 2001, as provided by FAA Air Traffic Security Coordinator Douglas Gould. I synthesized Mr. Gould’s assessment of the FAA threat response paradigm (circa 2001) into Table 3.

[148] The NPS Operations Research Department’s Simulation Experiments and Efficient Designs (SEED) Center provided significant support in the design and execution of this experiment.

[149] Zoe Henscheid, Donna Middleton, and Edmund Bitinas, “Pythagoras: An Agent-Based Simulation Environment,” *Scythe* 1, no. 1 (2005): 40–44.

Table 3. FAA Threat Response to Aviation Anomalies (circa 2001)

Aviation Anomalous Event	**Impact on Threat Detection**
Commercial aircraft fails to make a scheduled altitude change	25% more likely to identify a threat and initiate a crisis response
Commercial aircraft makes an unexpected altitude change	50% more likely to identify a threat and initiate a crisis response
Commercial aircraft's transponder stops transmitting	50% more likely to identify a threat and initiate a crisis response
Commercial aircraft fails to respond to FAA communication	50% more likely to identify a threat and initiate a crisis response
FAA intercepts suspicious transmissions from aircraft	50% more likely to identify a threat and initiate a crisis response
FAA receives messages from crew/passengers suggestive of violence and/or hijackers onboard	75% more likely to identify a threat and initiate a crisis response

In order to provide meaningful and reliable data, the experiment incorporated two standard practices for simulations. First, I replicated the model a statistically sufficient number of times for each variation of initial threat detection probability. Sanchez explains the statistical need for replicated simulations as "a way to gain enough data to achieve narrow confidence intervals [or higher levels of precision] and powerful hypothesis tests, or for graphical methods to reveal the important characteristics of your simulation model."[150] Second, I ran the model *stochastically* to represent the uncertainty of the real world.[151] The Pythagoras simulation suite automatically engineers stochastic or random results through the use of probabilities to govern virtual agent behavior. In addition, I used non-zero tolerances associated with several of the Pythagoras parameters to allow additional variance within the virtual dice rolls that determine the outcome of agent interactions. A tolerance in Pythagoras represents the "plus or minus" quantity associated with a numerical value. Thus, if the programmed probability of an event

150 Sanchez, "Work Smarter," 69.

151 A *stochastic* simulation implies the integration of randomness or a random distribution of results.

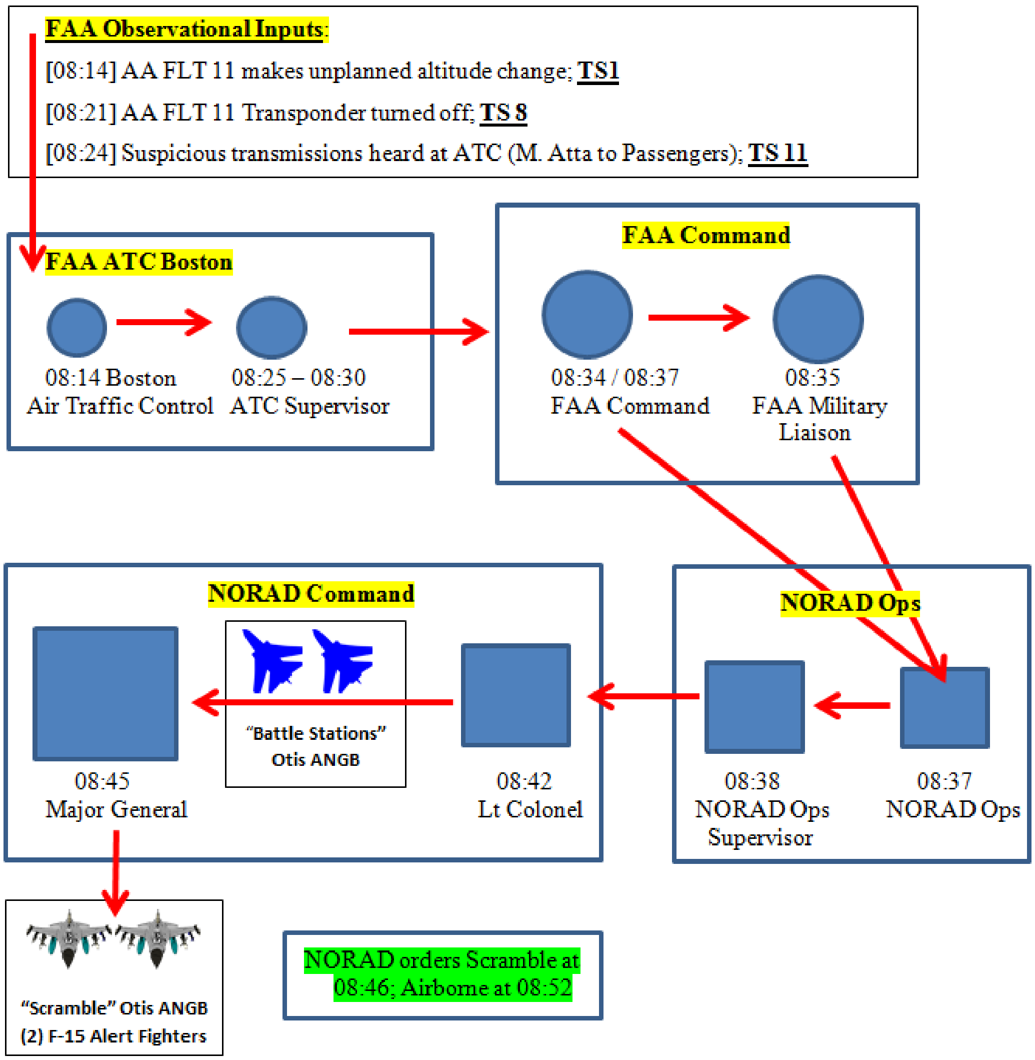
occurring is 50 percent with a tolerance of .05, the actual probability that event will occur will vary between 45 percent and 55 percent for each run of that simulation. The integration of randomness into the virtual environment produces a variability among possible outcomes that effectively mimics real life.

1. The 9/11 Control Experiment

The initial phase of the experiment, the control phase, simulated the FAA/NORAD decisions as they actually happened on the morning of September 11. To prepare the simulation design, I used empirical data to map out the timing and flow of the events that took place on September 11 (see Figure 5).[152] Relying on this information, I constructed the logic rules that govern the interactions between virtual agents and with the specific aviation anomalies that occurred during the event. The Pythagoras software refers to these interactions as *triggers*.

[152] Data obtained from the National Commission on Terrorist Attacks, *The 9/11 Commission Report*.

EMPIRICAL DATA FOR SIMULATION – “MUSCLE MOVEMENTS”



SIMPLIFIED MUSCLE MOVEMENTS FOR SIMULATION:

1. Initial ATC Boston identification of threat and contacts FAA Command.
2. FAA Command is persuaded of threat and contacts NORAD Ops.
3. NORAD Ops is persuaded of threat and contacts NORAD Command.
4. NORAD Command is persuaded of threat and orders SCRAMBLE.

Figure 5. Simulation Muscle Movements

For the control simulation, the FAA Boston Air Traffic Controller (ATC Boston) virtual agent—representing the actual ATC who dealt with American Airlines Flight 11—is defined as part of the red team. The experiment begins at time step 0, the analogue to 8:14 a.m. (EST) when Flight 11 made an unscheduled altitude change. This incident was the first observed aviation anomaly related to Flight 11 and the initial indicator of the September 11 attacks. The simulation progresses through incremental time steps, each representing one minute of actual time. The experiment allows the ATC Boston virtual agent one opportunity per time step to detect the Flight 11 virtual agent as a threat.

During the initial time steps, the logic rules allow the ATC Boston agent a 50 percent chance of detecting Flight 11 as a threat. This detection probability is a programmed behavioral rule based on the FAA's standardized response (circa 2001) when a commercial airplane makes an unscheduled altitude change. At time step 7, or 8:21 a.m., the probability of detecting Flight 11 as a threat increases with the subsequent aviation anomaly of Flight 11's transponder shutting down. At time step 10, or 8:24 a.m., the probability of detecting Flight 11 as a threat increases again with the aviation anomaly of suspicious transmissions received from Flight 11.

The actual FAA Boston ATC took approximately 11 minutes to identify Flight 11 as a threat and elevate the issue to his supervisor. The simulation approximates that result by assigning the ATC Boston agent an initial 50 percent chance of detecting the Flight 11 agent, and then increases this probability with each additional aviation anomaly. Each time the ATC Boston agent successfully detects Flight 11 as a threat within the simulation, he becomes "more convinced" of Flight 11's threat, which the simulation represents by incrementally changing his team color to become less red and more green.

Once the agent's color turns more than 50 percent green, the simulation considers him sufficiently convinced that Flight 11 is a threat. As illustrated in Figure 6, the simulation then re-codes the agent's marker as an "X" and directs him toward the next decision maker in the chain of command.

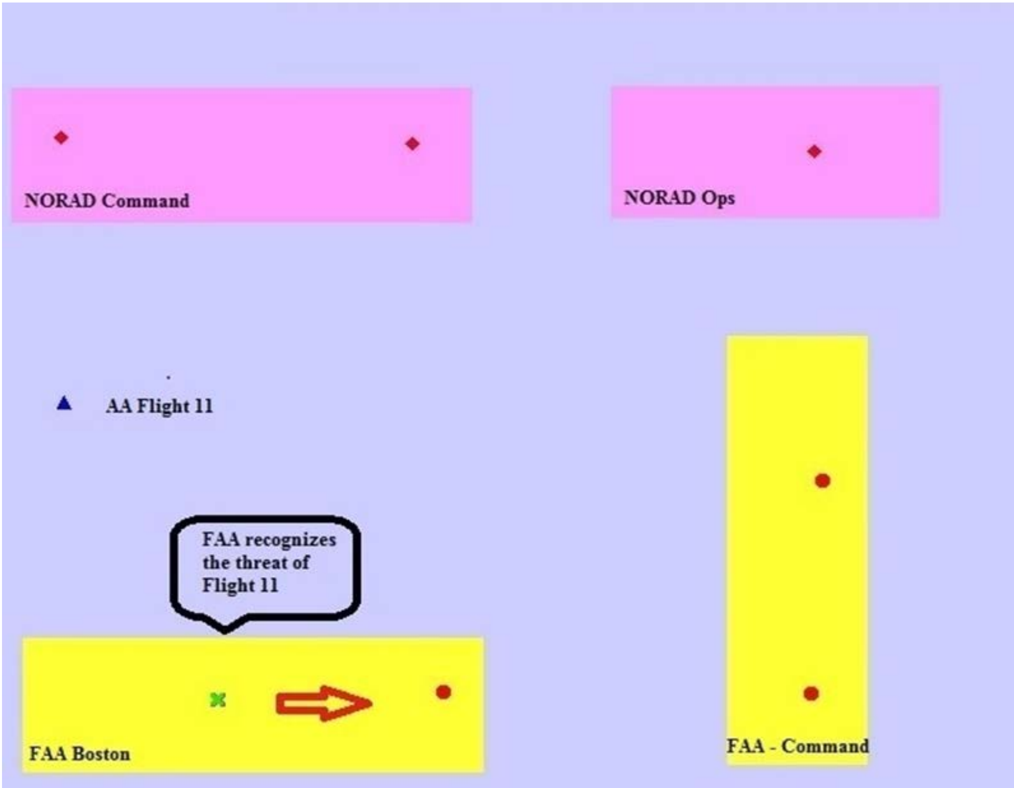


Figure 6. Initial Stage of 9/11 Simulation

At this point in the simulation, the first agent interacts with the next according to a new set of behavioral rules. In this case, the green agent fires a virtual green paintball at the next agent in the chain of command, which simulates the process of convincing him that Flight 11 is a threat. The concept of persuading a simulation agent via hits from a virtual paintball gun is a technique called *surrogation*; the paintball hit is a surrogate for a successful persuasion attempt by another agent in the model. The moment when the second agent is hit enough times to turn more than 50 percent green—the surrogate for becoming sufficiently convinced of the Flight 11 threat—the simulation rules direct him toward the next agent in the chain of command (Figure 7).

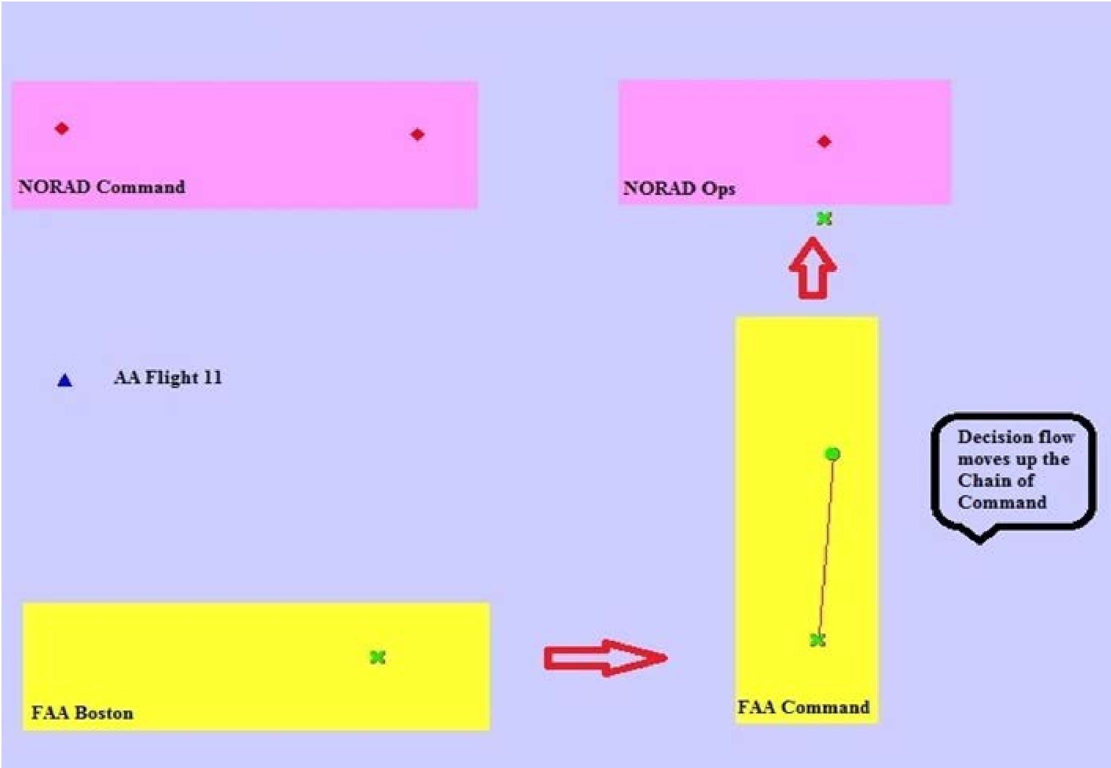


Figure 7. Interim Stage of 9/11 Simulation

The process continues until the final agent becomes sufficiently convinced and "attacks" the Flight 11 agent with virtual paintballs, which is the surrogate for NORAD's decision to launch intercept fighters (Figure 8). This actual decision took place at 8:46 a.m. on September 11, 2001, analogous to time step 32.

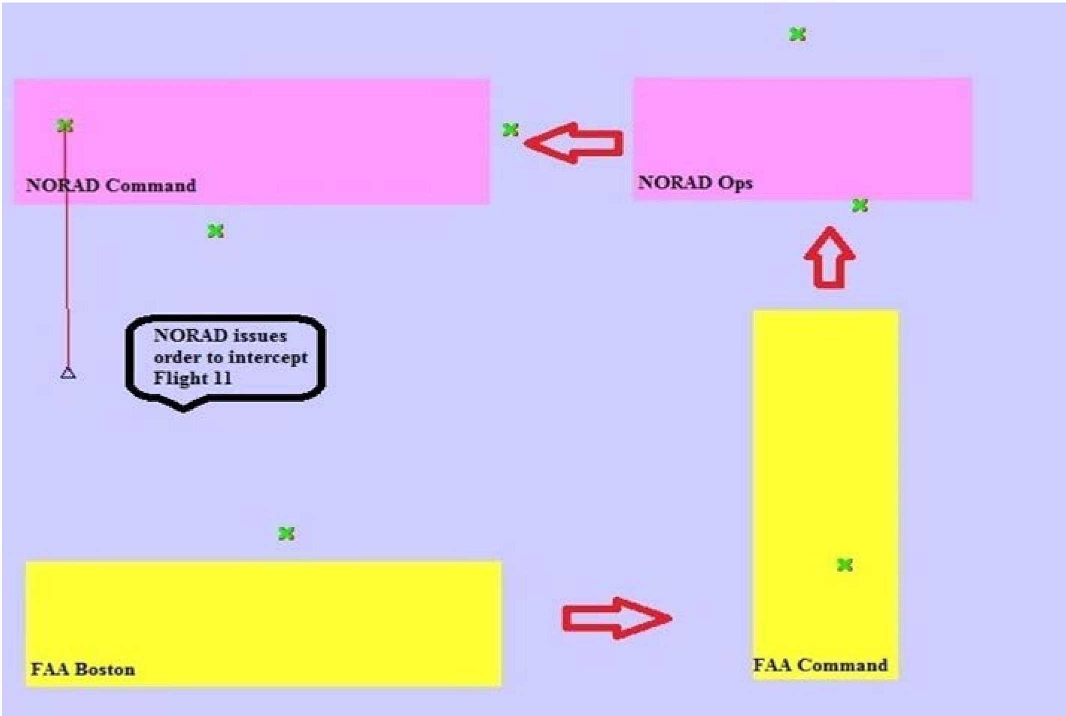


Figure 8. Final Stage of 9/11 Simulation

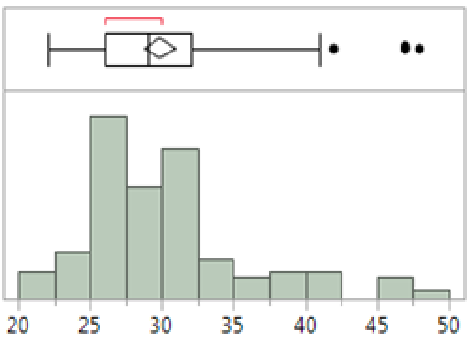
To obtain credible results from the control experiment, I ran the stochastic simulation 100 times. Figure 9 displays the results of the control experiment. The graphical display on the left side of Figure 9 illustrates the range of results from the 100 iterations. The histogram indicates that the distribution of experimental data approximates a normal distribution, which presents as a bell-shaped curve. The experimental data yielded a mean time of completion at time step 30, or 8:44 a.m. This result means that NORAD launched the alert fighters two time steps, or two minutes, faster in the simulation environment than during the actual event on September 11. The summary statistics yielded a standard deviation of 5.7, denoting that in the majority of iterations, the launch order was issued within six minutes on either side of the 8:44 a.m. average time.[153] NORAD actually ordered the launch at 8:46 a.m., the equivalent to time

[153] A principal characteristic of a normal (or *Gaussian*) distribution of data is that approximately 68 percent of all observations fall within one standard deviation of the mean. Wayne LaMorte, "The Normal Distribution: A Probability Model for a Continuous Outcome," Boston University School of Public Health, July 24, 2016, http://sphweb.bumc.bu.edu/otlt/mph-modules/bs/bs704_probability/bs704_probability8.html.

step 32, which falls within one standard deviation of the mean of the experiment. This outcome verifies that the control experiment is a reasonable and plausible simulation of the September 11 events.

Distributions

TimeComplete



Quantiles

100.0%	maximum	48
99.5%		48
97.5%		47
90.0%		38.9
75.0%	quartile	32
50.0%	median	29
25.0%	quartile	26
10.0%		24
2.5%		22
0.5%		22
0.0%	minimum	22

Summary Statistics

Mean	29.88
Std Dev	5.7088979
Std Err Mean	0.5708898
Upper 95% Mean	31.012769
Lower 95% Mean	28.747231
N	100

Figure 9. Distributions from the Control Simulation Experiment

2. The Adaptive SOP Enhancement Experiment

After testing the simulation environment to verify that its logic rules produced credible results, I designed an experiment to evaluate whether an adaptive SOP could have improved the September 11 crisis response. To obtain a demonstrable range of results, I incrementally increased the ATC Boston agent's initial chance to identify Flight 11 as a threat by 5 percent and ran the simulation 100 times at each 5 percent increment. The increase in initial detection probability for the ATC Boston virtual agent approximates the hypothetical improvement facilitated by the adaptive design proposals.

The purpose of modifying the initial detection probability and running the experiment at each increment was to identify *how much* of an increase in the agent's ability to detect an unexpected threat is required to improve the outcome of the scenario. If the simulation results suggest the proposed SOP re-design must produce substantial improvements to significantly change the scenario outcome, the adaptive design proposals may not be worth the effort. Conversely, if the simulation results demonstrate that the SOP re-design only needs to yield a modest increase in the agent's ability to significantly improve the outcome, decision makers should be more convinced of the merits associated with implementing the adaptive design proposals. The second experiment allows decision makers to visualize the potential benefits of implementing the adaptive design proposals.

I determined that the goal of this experiment—the point at which the adaptive design proposals achieve a meaningful improvement in the scenario outcome—was to prompt the order to launch alert fighters in time to intercept United Airlines Flight 175. Flight 175 was the second airliner to strike the World Trade Center, hitting the South Tower at 9:03 a.m. The alert fighters require 23 minutes from the launch order to travel 150 miles to New York City.[154] Considering these factors, the virtual NORAD needs to order the launch at 8:37 a.m. for the alert fighters to be in the vicinity of New York City by 9:00 a.m., allowing a three-minute window of opportunity for the military aircraft to intercept Flight 175 before it strikes the South Tower. In simulation terms, the goal of the experiment is to identify the percentage of improvement in the ATC Boston virtual agent's threat-detection ability required to complete the simulation by time step 23. After running the simulation 100 times for each incremental increase in the ATC Boston agent's detection ability, I analyzed the data distribution from each series. As presented in the next section, the graphical representation of the results allowed a straightforward comparison of the experimental data against the stated goal of the simulation.

C. EXPERIMENT CONCLUSIONS

Figure 10 displays the distribution of experimental data across all 20 increments of the ATC Boston agent's percent improvement in initial threat detection (x-axis). The black horizontal line at time step 32, or 8:46 a.m., represents the time that NORAD actually gave the launch order on September 11. The green horizontal line represents the goal of the experiment, to obtain a launch order by time step 23, or 8:37 a.m. The vertical dots represent the range of results for each incremental simulation series. The red brackets represent the results that fall within one standard deviation of the mean for each

[154] Data obtained National Commission on Terrorist Attacks, *The 9/11 Commission Report*.

case, and the blue line connects the mean result for each series of percent improvement in detection ability.

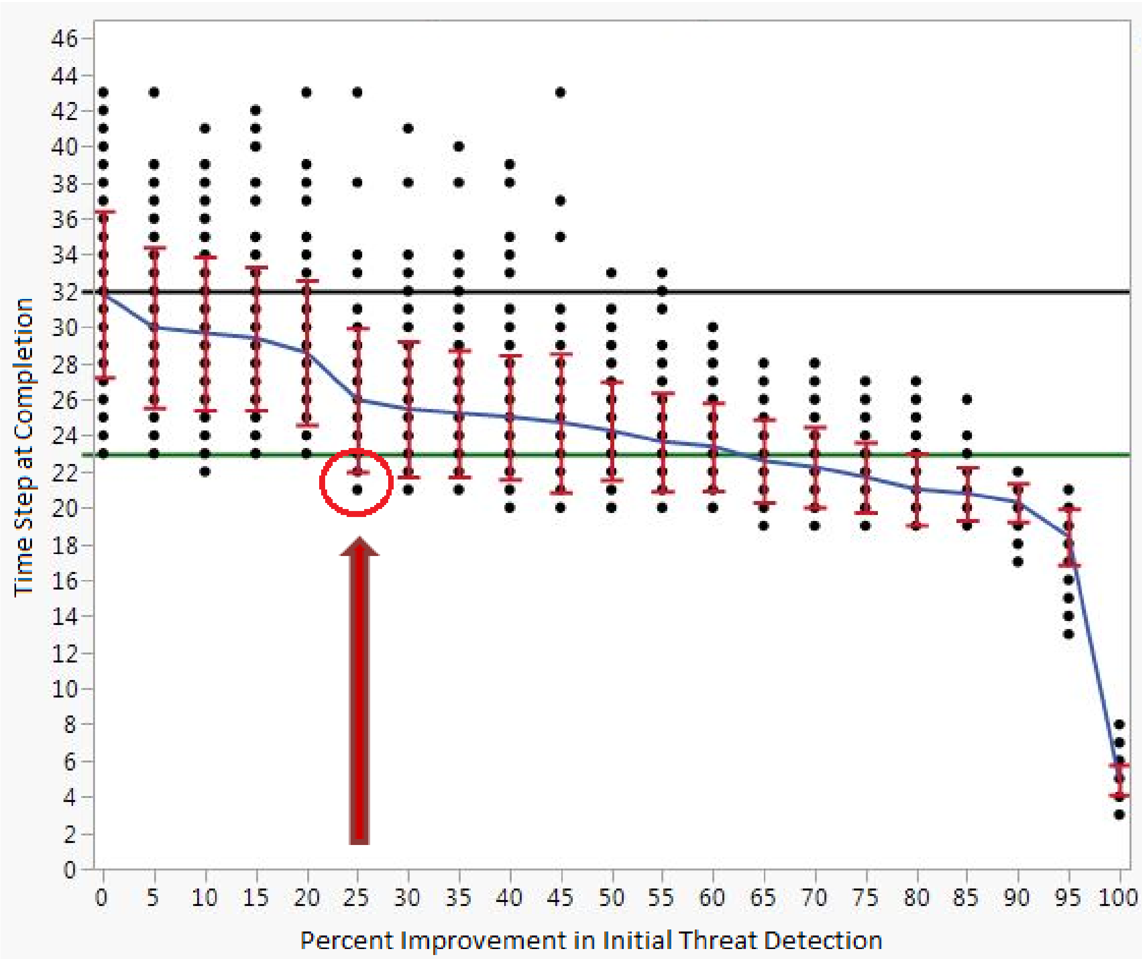


Figure 10. Distributions from the Adaptive SOP Enhancement Simulation Experiment

The graphical display of the experiment illustrates that the use of adaptive SOPs could significantly decrease reaction time with only a modest improvement in the ATC Boston's initial threat detection ability. As indicated within the table, the goal of completing the simulation by time step 23 falls within one standard deviation of the mean at the 25 percent increment. This outcome indicates that if the adaptive SOP response yielded a 25 percent improvement in threat detection, then it is statistically feasible that the alert fighters could have intercepted Flight 175. The simulation results demonstrate that the adaptive design proposals could theoretically yield a reasonable and significant benefit to the field of crisis response. Therefore, this experiment supports the argument for implementing the adaptive design proposals.

The adaptive SOP enhancement experiment was an exercise in counterfactual history intended to portray the prospective value of the adaptive design proposals. MAS simulation experiments cannot represent every nuance in human behavior or unpredicted influence in a complex system, so the experiment conclusions must appear as “if/then” statements rather than concrete assertions. Computer simulations are a product of theories, data, and educated guesses—they do not trade in absolutes. However, while these results are only hypothetical, they do effectively promote the adaptive design proposals by quantifying and visualizing their potential enhancements to the HSE emergency response paradigm.

The following conclusion chapter summarizes the thesis’ exploration of complexity theory and SOPs, the case study analysis of recent complex mega-crises, the presentation of the adaptive design proposals, and the adaptive SOP simulation experiment.

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VI. CONCLUSION

When responding to an emergency, crisis professionals must rely on their training, equipment, and experience, and act in accordance with standard operating procedures (SOPs). Ideally, the SOP checklist ensures consistent and successful performance by anticipating the operating environment and recommending appropriate actions. So long as the actual event adheres to the prediction, the SOP can assist responders who need to make effective choices in the field. Dilemmas arise when rapidly developing events diverge from expectation and the SOP guidance becomes less useful or even hampers response efforts.

This thesis tackled the problem of applying prediction-dependent SOPs in the complex twenty-first century crisis environment. Technological advancements in the digital age allow human beings to exert near-real time influence on each other and their environment. Sociologists who describe this hyper-connected world as a complex system assert that one of its quintessential characteristics is unpredictability. Modern crises also demonstrate elements of complexity, making agent interactions and emergent behavior difficult to anticipate. Unfortunately, while the characteristics of modern crises have evolved, the SOPs used to manage them have not.

Because complexity is essentially unpredictable, traditional SOPs become less effective in complex emergencies. Reliance on conditioned, checklist instructions instead of innovative, adaptive solutions can cripple emergency response when the actual outcome does not align with the anticipated course of the disaster. This is a challenge that hampers today's emergency responders whenever the crises diverge from expectations; the more significant the disaster, the more complex its behavior.

This thesis presented analysis of the September 11 attacks, Hurricane Katrina, and the Fukushima-Dai'ichi nuclear incident. These case studies illuminated the inadequacies of the traditional SOP model in complex disasters and offered adaptive design proposals to address this critical vulnerability. Complex mega-crises are worst-case scenarios for the misapplication of prediction-dependent SOPs in an unpredictable environment. The analysis and discussion presented in the case studies consistently found that SOP-driven responses were ineffective when the operational setting varied from expectations. The thesis also demonstrated that when crisis responses embraced adaptable, innovative solutions, they frequently yielded successful results despite the less predictable operational setting. The central conclusion from the case study analysis was that the fundamental unpredictability of complex emergencies demands an adaptable response approach that can change as the disaster itself changes.

Since traditional SOPs are too inflexible to impart effective direction in complex emergencies, the Homeland Security Enterprise (HSE) needs a method to incorporate adaptive, innovative qualities into its crisis response. This thesis began by asking the question: How can we integrate adaptability into SOPs? To develop answers to that central question, the work depended on current research in complex adaptive systems (CAS) theory, Lagadec's philosophical exploration of complex crises, and a practical application of the Socratic method to the emergency response standard. Based on the examination of this material, the thesis synthesized two prototype solutions that addressed the need for flexibility and innovation while allowing for the traditional use of SOP guidance in crisis response.

First, the work recommended a modification of pre-existing crisis SOPs to integrate adaptability prompts that stimulate critical thinking during an emergency. These modest changes to an HSE agency's SOP should help responders identify the unanticipated behavior of a complex emergency. Even more importantly, adaptability prompts compel the crisis professional to adjust the response plan to account for new information and the evolving needs of the moment. The adaptability prompt concept makes anticipating potential divergence from the expected event a principal theme for every emergency response.

The second adaptive design proposal makes a concerted effort to foster critical thinking within the crisis environment. The thesis recommends the creation of an ad hoc crisis advisory role, a crisis co-pilot, to help an emergency lead-responder employ Socratic reasoning in the field. The primary purpose of the crisis co-pilot is not to predict the unexpected, but to encourage the emergency lead-responder to challenge assumptions, anticipate the unexpected, and modify operational plans to manage the evolving crisis. The crisis co-pilot should help prevent myopic biases that can develop from static assumptions about the emergency.

Implementing institutional changes within the emergency response field is a challenging prospect. Agencies within the HSE have unique traditions and approaches to the management of their varying responsibilities. For this reason, the solutions proposed within this thesis are intentionally straightforward and widely applicable. In particular, the changes recommended to integrate adaptability into the HSE emergency response paradigm require minimal time and training. Simply stated, the adaptive design proposals are deliberately modest changes to the emergency responder's tool box, devised for quick and uncomplicated implementation in the field.

While ineffective SOPs do not presuppose the failure of emergency responders in every complex event—the quality of their experience and technology arguably overshadows the shortfalls of their rote guidelines—they remain a flawed yet fixable problem within the emergency response field. As such, this thesis proposed two executable methods to integrate adaptability into standardized emergency response. By incorporating adaptability prompts into crisis SOPs and instituting the role of a crisis co-pilot, response agencies within the HSE can more effectively manage complex emergencies. A re-designed SOP model that is more agile will guide crisis professionals to embrace adaptation when events deviate from the expected. Emergency responders will benefit from a support structure that fosters critical thinking in field operations. By implementing these steps to integrate adaptability into emergency response, HSE policy makers can better prepare their personnel to manage complex disasters and, in doing so, better protect their communities.

A. NEXT STEPS

Where do these concepts find a home? Ideally, the Federal Emergency Management Agency (FEMA) National Preparedness Directorate (NPD) would help introduce the adaptive design proposals into the emergency response community. NPD is an organizational component of FEMA that "provides the doctrine, programs, and resources to prepare the Nation to prevent, protect, mitigate, respond to and recover from disasters while minimizing the loss of lives, infrastructure, and property.”[155] The NPD mission encompasses all levels of government across a variety of emergency incidents. In particular, NPD’s National Preparedness Assessment Division (NPAD) is responsible for evaluating activities and innovations that promote all-hazards preparedness, and communicating these improvements across the U.S. emergency response community.[156]

NPAD’s operational structure is designed to identify gaps in the national preparedness paradigm and assess possible solutions or enhancements. Of particular relevance, NPAD has established the Lessons Learned and Continuous Improvement Program (LLCIP) to promote “preparedness by identifying lessons learned and innovative practices, analyzing recurring trends, and sharing knowledge with the whole community.”[157] This program has the unique capability to evaluate and develop new preparedness and response procedures for the emergency response field. As of 2015, the LLCIP archives its collected data at the Naval Postgraduate School’s Homeland Security Digital Library to allow centralized access for the entire HSE.[158] Policy makers could leverage the LLCIP to assess the adaptive design proposals and develop them into procedural recommendations for governmental crisis response.

B. AREAS FOR FURTHER RESEARCH

This thesis is an initial step to understand and manage the practical impacts of complexity on the modern crisis environment. The research and analysis presented here indicate a significant vulnerability in contemporary emergency response that deserves continued study. In that regard, scholars should expand the case study analysis presented in Chapter III to examine additional instances of modern complex disasters with a

[155] “National Preparedness Directorate,” Federal Emergency Management Agency, last updated August 2, 2016, www.fema.gov/national-preparedness-directorate.

[156] “National Preparedness Assessment Division,” Federal Emergency Management Agency, last updated January 11, 2016, www.fema.gov/ national-preparedness-assessment-division.

[157] Note: The Lessons Learned Information Sharing Program was renamed the Lessons Learned and Continuous Improvement Program. “Lessons Learned Information Sharing Program,” Federal Emergency Management Agency, last updated September 28, 2015, www.fema.gov/lessons-learned-information-sharing-program.

[158] Ibid.

particular focus on the comparative results of predictive versus emergent crisis responses. The scope of this thesis did not allow for more expansive case study and analysis. However, supplementary evaluations of crisis SOPs and emergent response behavior *in action* may yield a better understanding of the dilemma created when crisis professionals apply predictive responses to unpredictable events.

Further study is also warranted to explore the integration of adaptability within other areas of CAS research, particularly in the emerging field of *intelligent technology*. Louise Comfort et al. espouse the development of Interactive Intelligent Spatial Information Systems (IISIS), computerized information systems designed to interpret unfolding crises and recommend mitigation responses.[159] The crisis analysis and recommendations produced by an IISIS would ideally account for the influences of complexity within the environment. By incorporating an expectation of less-predictable emergency events and the need for adaptive, innovative responses, an IISIS may provide more effective advice to crisis professionals in the same fashion that the adaptive design proposals may improve SOP guidance.

Finally, the field of emergency response would benefit from directed research into a crisis professional's dependence on decision support tools like an SOP checklist while under duress. As discussed in Chapter II, the works of Hales and Pronovost identify and explore human beings' diminished ability to make rational decisions under significant pressure: "Human error is inevitable—particularly under stressful conditions. It has been demonstrated that levels of cognitive function are compromised as stress and fatigue level increase."[160] Understanding the need for decision support tools when operating in a high-stress environment may identify additional ways to build adaptability into tomorrow's crisis SOPs.

[159] Comfort et al., "Complex Systems in Crisis," 144–158.

[160] Hales and Pronovost, "The Checklist," 231–235.

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