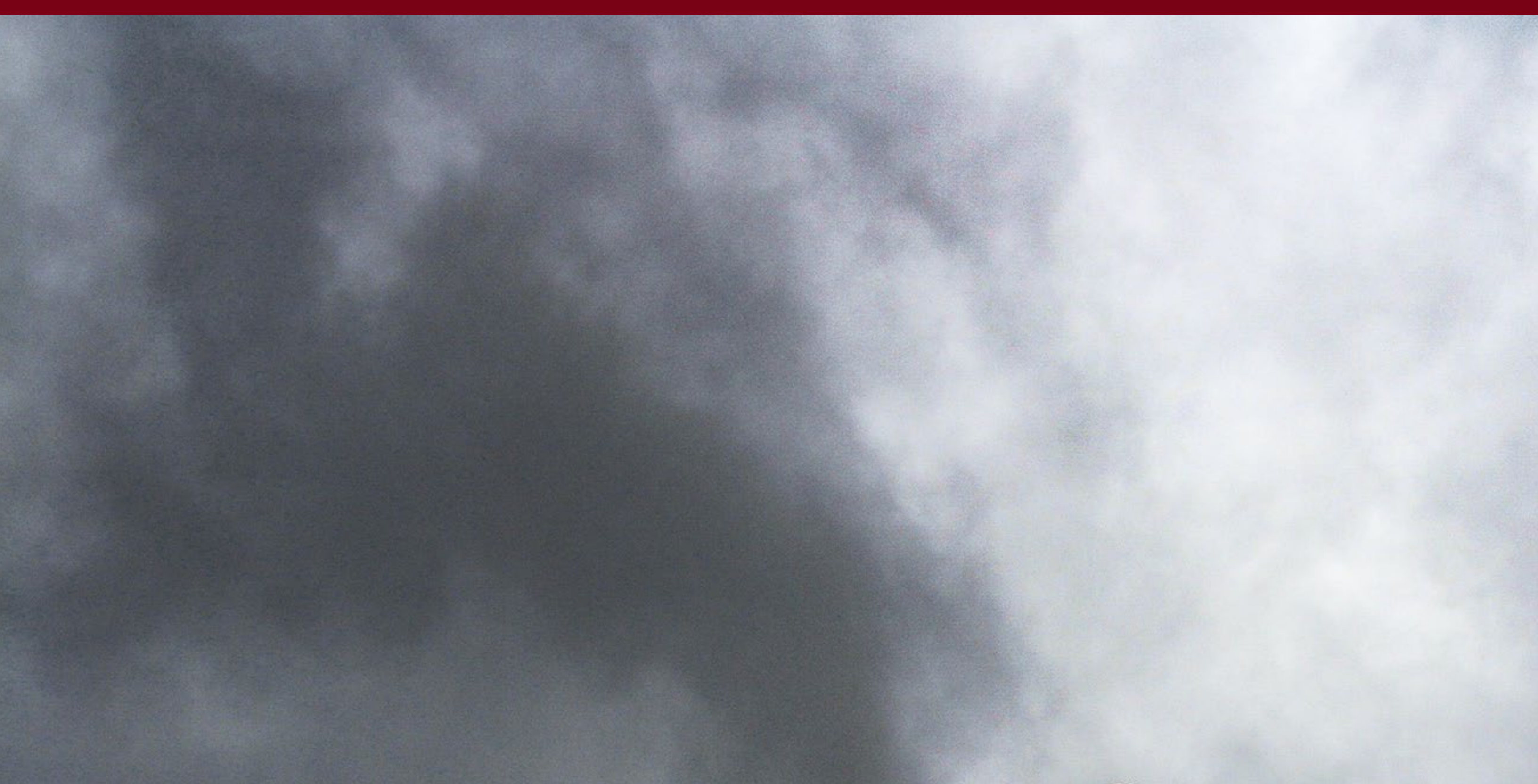
The Case for Adaptive SOPs in Complex Crises and Unpredictable Operating Environments

By Shawn Harwood and Wayne Porter, Ph.D.



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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 prediction-defiant scenarios yields ineffective emergency management, meanwhile case studies demonstrate that adaptation and innovative behavior often succeeds in the complex environment. If adaptability mitigates complex problems, then modern crisis SOPs must embrace an adaptive approach.

This article explores the "Disaster Dilemma" of applying predictive SOPs to unpredictable, complex disasters, to include a case study of a modern mega-crisis that argues for integrating critical thinking and adaptability into crisis response. The article presents the findings of a computer simulation of Air Traffic Controller responses during the September 11th terror attacks, quantifying hypothetical improvements in response times attained by integrating adaptability into crisis response. Finally, the article proposes two practical means of building adaptive behaviors into SOP-driven crisis response. Today's emergency response paradigm must evolve, acclimating to the unpredictable nature of complex crisis environments.

Introduction

The nature of disasters has evolved, but emergency management has not kept pace with the change. Owing to the nature of our complex, globalized society, today's crisis environment is subject to countless influences that result in random and volatile events. Despite the unpredictability of today's crisis arena, the emergency management field still adheres to prediction-dependent SOPs to guide response efforts. As a result, police, firefighters, and other crisis professionals are less able to manage modern, unpredictable events.

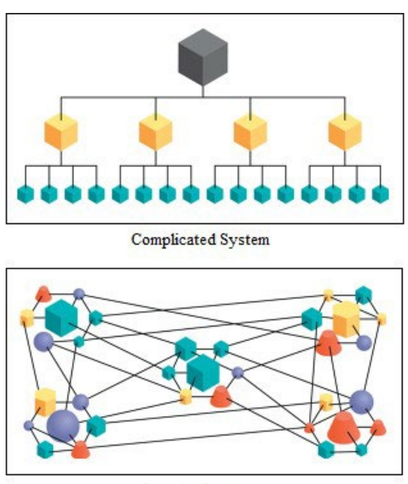
The traditional SOP anticipates an operating environment and provides a checklist of recommended actions to accomplish an objective. Sociologists Charles Parker and Eric Stern assert that "SOPs are based on past experience and expectation."[1] As long as the actual event adheres to the prediction, personnel can rely on an SOP to impart relevant guidance. However, the late twentieth century produced technological improvements in telecommunication and information sharing that, in turn, yielded a new, globally interconnected environment.[2] This significant increase in connectivity and concomitant feedback within local, regional, and global systems increased the *complexity* of many social networks. Sociologists David Snowden and Mary Boone describe complexity analysis as a way of understanding the behavior of large numbers of agents dynamically reacting to and influencing each other within a system.[3]

One of the essential characteristics of complex systems is that behavioral outcomes are often non-intuitive and difficult to predict. Modern disasters can also demonstrate complex characteristics, emerging quickly and developing in unexpected ways.

Dependence on rote procedure while operating in high-stress conditions is a flawed but understandable behavior within complex environments. A variety of work is available that examines performance and decision making in a modern crisis setting; this article builds upon the significant findings of Snowden and Boone, Parker and Stern, and others. Conclusions from the fields of sociology and behavioral psychology help clarify that the argument against conditioned, pre-planned disaster SOPs is not simply a procedural discussion, it is also an assessment of fallible human behavior and decision making in today's crisis environment. Sociologists Hales and Pronovost claim that when judgment and proficiency diminish in a high-stress setting, responders often resort to checklists and other cognitive aids in an effort to maintain efficiency.[4] Therefore, the crisis professional in a complex disaster is even more likely to cling to a rigid, ineffective SOP – further decreasing the likelihood of identifying and mitigating the unexpected. This article addresses the dilemma of prediction-dependent SOPs applied to prediction-defiant events from the central hypothesis that success within a complex environment requires adaptability.

Problem Statement: Complexity Versus Prediction

Toward the end of the twentieth century, tremendous improvements in communication and information sharing produced a technological ecosystem able to connect human interests around the world. As Uhl-Bien et al. state, "21st century organizations are facing a complex competitive landscape driven largely by globalization and the technological revolution."[5] 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 (linear and deterministic) working environment, their relationships often yielded an orderly, predictable outcome. Figure 1 illustrates the difference between a complicated and a complex (non-linear and probabilistic) system.



Complicated System

Complex System

Figure 1. Complicated System versus Complex System[6]

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. Emergent events and outcomes are the by-products of nonlinear reactions among agents within the system. Snowden and Boone further clarify the significant influence of elements interacting within a complex system: "[t]he interactions are nonlinear, and minor changes can produce disproportionately major consequences."[7] The principles of complexity apply to the modern crisis environment as well. McChrystal et al. make the claim that man-made disasters can exhibit the characteristics of a complex system: "[n]ew 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."[8] Today's complex environment allows terrorist groups to coordinate attack strategies with a mobile 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.[9]

The Standard Operating Procedure

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. Government agencies depend on SOPs to respond to the operating environment and provide a checklist of recommended actions that conform to official policy. The SOP model attempts to facilitate consistency in executing mission goals by promoting rote behavior. 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 for their response. As shown in Figure 2, the Chicago Police Department's Active Shooter Incident Plan (circa 2008) exemplifies a highly specific crisis SOP for police officers.

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 of discover wounded persons in and around the location, they will provide their exact locations to OEMC.

Figure 2. Excerpt from Chicago Police Department's Active Shooter Incident Plan[10]

These checklist police procedures do not recognize or allow for unanticipated and nonlinear complexity and behavior in the scenario. Instead, this example assumes that active shooters behave in predictable ways that correspond with the anticipated event, but what happens if the active shooter has 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? Generally speaking, there are innumerable influences that affect human behavior (e.g. emotions, environment, morality), so that an individual's choices and conduct must also reflect a complex system's characteristic unpredictability. Crisis professionals should expect human beings to take unanticipated actions and engage in nonlinear behavior that severely limits the effectiveness of a prediction-dependent SOP.

Psychologist and Nobel Prize winner Daniel Kahneman provides an interesting counterpoint to the alleged problem of ineffective SOPs applied to complex crises. He theorizes that the "everyday" experience of emergency responders refines their decision-making acumen to an instinctual level. This reflexive response would enable crisis professionals to react swiftly and effectively to unanticipated developments, regardless of ineffectual SOP guidance.[11] Kahneman argues that a veteran crisis responder's actions are primarily guided by experience, rendering checklist SOPs irrelevant. That said, he also cautions that such decision-making will always be a risky proposition – even for veteran responders – and that for less experienced personnel, or those subjected to unique situations, instinctual reactions (or what he refers to as "fast thinking") can have disastrous results.

Case Study: The Disaster Dilemma in Action

As previously stated, crises often demonstrate the prediction-defiant characteristics of complexity. In a complex emergency, the SOP may be of limited use if the actual event deviates from its anticipated behavior. This is the Disaster Dilemma. The September 11th terror attacks exhibited the characteristics of a complex event. As a case study, this mega-crisis affords the opportunity to assess the actual SOP-driven responses and compare them to a counterfactual adaptive approach, thereby exploring the article's central hypothesis that success within a complex environment requires adaptability.

September 11th 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 into 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 11th was the most significant crisis in American history in terms of lives lost, economic impact, and damage to the nation's sense of security.

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.[12] FAA officers applied the agency hijacking SOP to the unfolding crisis even after the hijackers' behavior deviated from expectations. The responding FAA officers adhered to the hijacking protocol by attempting to communicate with the pilots and coordinate support from NORAD. However, these efforts were ultimately irrelevant as the actual crisis was a terror attack, not a hijacking. The FAA's attempt to respond to the wrong type of crisis wasted time that could have been spent assessing and responding to the true nature of the event.

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. FAA National Operations Manager Ben Sliney eventually departed from agency SOPs when he grounded all commercial flights across the United States.[13] 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.

As illustrated in this case study, while SOP-driven preparations and actions often hindered crisis response efforts, many emergency responders were able to navigate the complex environment by taking a flexible, adaptive approach.[14] With regard to the September 11th crisis response, analysts James Kendra and Tricia Wachtendorf assert that "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."[15] The FAA did achieve minor success by departing from SOP guidance to communicate directly with NORAD. As the 9/11 Commission reported, "[l]ower-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."[16]

The U.S. Coast Guard (USCG) evacuation of the waters surrounding lower Manhattan was an even stronger example of adaptive disaster mitigation. USCG 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."[17] These efforts did not succeed by adherence to agency SOP; rather, success resulted from 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 routinely worked in and around the World Trade Center disaster site, emergent groups of private citizens *self-organized* to meet 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 and rendered assistance in a decentralized fashion as they identified various needs in the crisis environment. Perhaps the most poignant example of successful, adaptive behavior was the self-organized response from the passengers aboard United Airlines Flight 93 that kept the terrorists on their flight from achieving their goal.[18] As sociologist Kathleen 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."[19] These emergent groups were uniquely suited to operate in the complex crisis environment on September 11th, as the needs of the moment inspired improvisational solutions in the absence of SOP guidance.

The SOPs on which various crisis planning and response entities relied during the September 11th events were often ineffectual because they applied prediction-dependent guidance in complex environments. When officials realized that the nature of the threat had significantly deviated from the initial assessment, there was little time to mitigate the actual crisis. The day's operational successes consistently demonstrated examples of adaptive decision making. 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. The analysis based on the September 11 terror attack case study supports the central hypothesis that success within a complex environment requires adaptability.

Adaptive SOP Design Proposals

If we accept that the case study argues in favor of integrating adaptability into modern crisis response, the next question must be: *how can we integrate adaptability into crisis response SOPs?* In their current form, 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. Analysts Michael Bolton and Gregory 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."[20] The onset of spontaneous, unexpected problems within a crisis is the hallmark of the prediction-defiant complex environment. Based on the previous discussions of complexity and its unique impact on modern crisis environments (as illustrated in the September 11 case study), it appears that SOPs lack the adaptability required to impart effective guidance in a complex disaster. Therefore, proposals for an adaptive redesign of the crisis SOP model must rely upon more than concrete sets of instructions; they must serve as decision support systems that help crisis professionals navigate a dynamic and complex disaster environment.

The integration of adaptability into emergency response is effectively the encouragement of critical thinking during a crisis. As such, the Socratic method of inquiry, sometimes referred to as the *dialectic method*, plays a fundamental role in the following recommendations. Complexity scholars Richard Paul and Linda Elder describe the Socratic method as a cognitive process intended to stimulate critical thinking and comprehension through a dialogue of questions and answers, rather than simple rote learning. They call on readers to "[r]ecognize 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."[21] 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 and identify the unexpected in an evolving scenario.

Adaptive Design Proposal #1 – Adaptability Prompts

Can SOP guidance devised to standardize action evolve to promote flexibility and critical thinking? The first design proposal attempts to answer that question with the integration of instructive prompts 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 to evaluate how these changes should modify the crisis response. To illustrate the concept, Table 2 presents the Chicago Police Department's SOP for active shooters (introduced as Table 1), 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 expectation?
      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 of discover wounded persons in and around the location, they will provide their exact locations to OEMC.

Figure 3. Active Shooter SOP with Adaptability Prompts[22]

Based on the Socratic questioning principle, adaptability prompts stimulate critical thinking, thus constituting an evaluative (and re-evaluative) process for understanding a problem. This adaptive SOP design relies on those same principles to encourage crisis responders to evaluate regularly 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 unpredictable emergencies. Lagadec and Topper argue that crisis responders must learn to expect surprises in complex emergency scenarios and plan to revise response actions accordingly.[23] Lagadec calls for institutional reform of the modern crisis response paradigm: "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."[24] Adaptability prompts are improvements to SOPs—one of the fundamental tools used in crisis response—that could enhance awareness of the complexity in the field and to promote adaptable behavior.

Adaptive Design Proposal #2 – Crisis Co-pilot

Teachers of the Socratic method serve as a guide for their students' cognitive processes, correcting the pursuit of flawed or erroneous assumptions. Rick Whitely asserts that, "[a]s 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."[25] Crisis professionals would benefit from similar assistance to keep their cognitive process consistent with the Socratic emphasis on critical thinking during a complex emergency. Lagadec and Topper recommended employing cognitive assistance during an emergency. They developed the concept of a *rapid reflection force* whose purpose is "to help the leader to grasp and confront issues raised by unconventional situations."[26] They argued that the responsibility of leading emergency response actions, while simultaneously evaluating and re-evaluating the crisis environment, is a task that could exceed the capacity of a single person.

Lagadec describes the emergency responder as a "crisis pilot" who navigates the unexpected to mitigate a complex disaster.[27] In deference to his work, the second adaptive design proposal recommends instituting a *crisis co-pilot*. This concept synthesizes elements of the Socratic method as well as Lagadec and Topper's rapid reflection force to create a professional role within the emergency response field that supports the primary emergency responder in an advisory capacity. The crisis co-pilot assists the lead emergency responder by reinforcing the aforementioned 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 address the unexpected. This role could be performed by a member of an emergency response team in the field or remotely via a 911 "tactical" dispatch officer or similar.

The next section of this article will use a computer simulation experiment to answer the research question, "how effective is adaptive crisis response?"

Multi-Agent System Simulation: The Effect of Increased Adaptability in a Complex Case Study

Whether deliberating a procurement request or a law-enforcement field operation, decision makers are expected to evaluate the prospective benefits and likelihood of success before committing personnel and resources.[28] This process is challenging as it requires an estimation of a proposal's potential. The evaluator must play the role of fortune teller to produce an analysis of future performance. Fortunately, modern computing advancements have improved the forecasting powers of government leaders.

Multi-Agent System Simulations (MAS) are frameworks that approximate human decisions within a virtual system to identify the best means for achieving a desired outcome. Pan et al. describe this scientific methodology as "an artificial environment populated with autonomous agents, which are capable of interacting with each other."[29] 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.[30] By following a set of behavioral rules, computer simulations can approximate human cognitive processes. The computer simulation assigns probabilities that agents in the scenario will make specific choices, incorporating elements of randomness, which produce statistically-relevant results and a convincing imitation of reality.

Heuristic 9/11 Simulation Experiments

To assess the central hypothesis of the effects of increased adaptability in complex environs, this article presents a heuristic MAS simulation based on historical data from the September 11th terror attacks. This simulation provides the opportunity to measure the potential value of employing an adaptive crisis response against the prediction-dependent SOP approach. Case studies provide examples of an adaptive approach improving crisis response. The adaptive response designs presented above outline strategic recommendations for integrating adaptability into an SOP framework. The simulation to follow will attempt to quantify the theoretical impact of integrating the adaptive SOP redesigns into modern disaster response – helping to clarify if the proposed changes would be worth the effort, time, and expense.

The simulation focuses on the crisis response decisions made by the FAA and NORAD on the morning of September 11, 2001.[31] The logic rules governing the behavior of the virtual agents are based on empirical observations taken from official accounts of the September 11th attacks and on a professional assessment of the FAA response paradigm to aviation anomalies in 2001, which is synthesized in Table 1.[32] While these governing probabilities are based on observational data and assigned specific values through collaboration with a career FAA Air Traffic Security professional, the end result remains a subjective assessment of a complex environment and a set of theoretical interventions introduced into a crisis scenario. As such, the simulation research as a practical assessment of the adaptive SOP proposals is limited by its purely hypothetical foundation.

Table 1. 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

The initial phase of the experiment – the control phase – simulated the FAA/NORAD decisions as they actually happened on the morning of September 11th. To prepare the simulation design, empirical data supplies the timing and flow of the events that took place on the day of the attack (see Figure 4).[33]

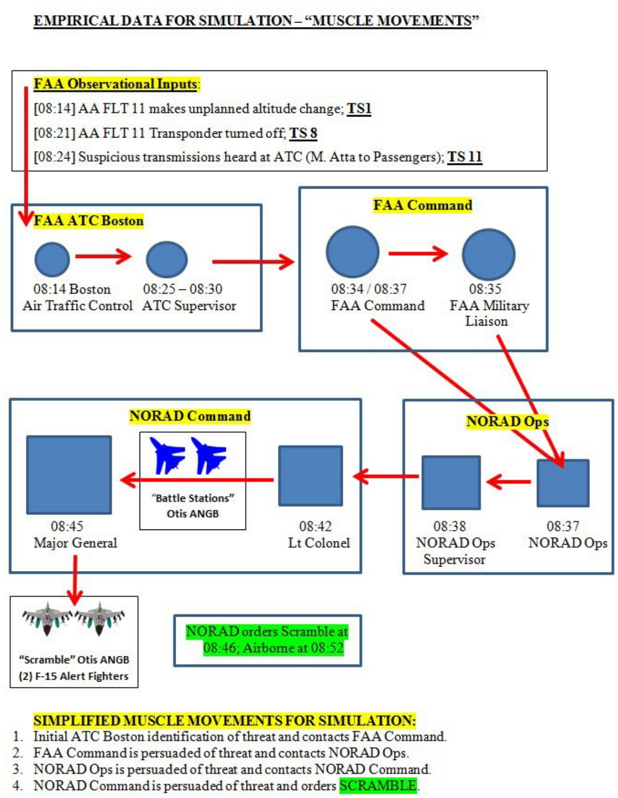


Figure 4. September 11th Attack - Flow of Events

Relying on this information, logic rules govern the interactions between virtual agents and represent specific aviation anomalies that occurred during the event. For the control simulation, the FAA Boston Air Traffic Controller (ATC Boston) was represented by a virtual agent and the experiment began 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 11th 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.

At the beginning of the simulation (time step 0), 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 demonstrates an aviation anomaly. With every subsequent irregularity, the probability that the virtual ATC Boston agent will detect Flight 11 as a threat increases – simulating an increasing suspicion of danger. Using the aforementioned logic rules, the simulation successfully approximates the actual cycle of crisis identification and escalation during the September 11 terror attacks, represented in Figures 5, 6, and 7 from the simulation experiment. When the virtual agents become "convinced of the threat," they convert from a red circle to a green X in the simulation environment and notify the next virtual agent in the chain of command, who replicates the same identification and escalation virtual process. The simulation continues until the final agent becomes sufficiently convinced there is a threat and engages the Flight 11 simulated agent (the surrogate for NORAD's decision to launch intercept fighters) at 8:46 a.m. on September 11, 2001, analogous to time step 32.

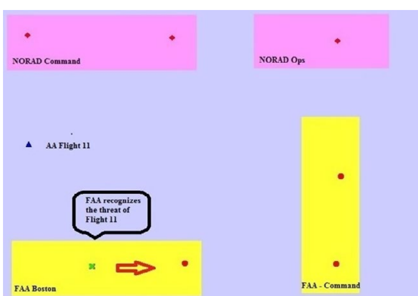


Figure 5. Initial Stage of 9/11 Simulation

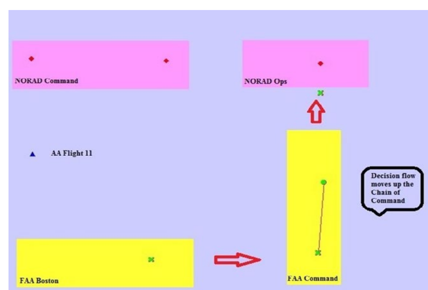


Figure 6. Interim Stage of 9/11 Simulation

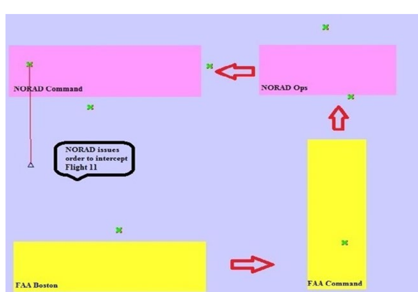


Figure 7. Final Stage of 9/11 Simulation

After executing the control simulation a statistically significant number of times (100 stochastic simulation runs) and analyzing the results, the summary statistics confirmed that the experiment consistently yielded a decision to launch alert fighters within one standard deviation of time step. [32] The control experiment was therefore a reasonable and plausible simulation of the September 11th events. With an accurate control simulation established, the second phase of the experiment could provide an effective environment to test the theoretical benefits of the adaptive SOP redesigns.

The phase two experiment seeks to quantify the value of integrating critical thinking and adaptability into crisis management by testing for an improvement in the September 11th time of response. It is important to note that systems modeling must often incorporate counterfactual assumptions or prospective policies and actions to evaluate potential outcomes. Specifically, the simulation in this second experiment assumes that the FAA and NORAD have implemented the adaptive SOP redesigns described in the previous section, prompting improvements in their responders' ability to identify and mitigate the unexpected elements of the September 11th crisis. To obtain a demonstrable range of results, the ATC Boston agent's initial chance to identify Flight 11 as a threat incrementally increases by five percent and the simulation runs 100 times at each five percent increment. The increase in initial detection probability for the ATC Boston virtual agent approximates the hypothetical improvement facilitated by incorporating innovation and adaptability into the crisis response.

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. It was reasoned that if the simulation results suggest the more adaptive approach must produce *substantial* improvements to change significantly the scenario outcome, then decision makers may determine that integrating adaptability and critical thinking may not be worth the time, expense, and effort. If the simulation results demonstrate that an adaptable approach simply needs to yield a modest improvement in crisis response to improve significantly the outcome, then decision makers should be more convinced of the value in implementing adaptive procedures to crisis response.

Findings and Recommendations:

The goal of this experiment was to identify the point at which the order to launch alert fighters in time to intercept United Airlines Flight 175 should have been made: the point at which adaptive crisis response would have achieved a meaningful improvement in the scenario outcome. 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.[34] 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 intercept simulation by time step 23. After running the simulation 100 times for each incremental increase in the ATC Boston agent's detection ability, the data distribution from each series can be analyzed, allowing a comparison of the experimental data against the stated goal of the simulation.

Experiment Conclusions and the Central Hypothesis

Figure 8 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 11th. 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 case, and the blue line connects the mean result for each series of percent improvement in detection ability.

The graphical display of the experiment illustrates that the integration of adaptability and innovation could significantly decrease reaction time with only a modest improvement in the ATC Boston's initial threat detection ability.

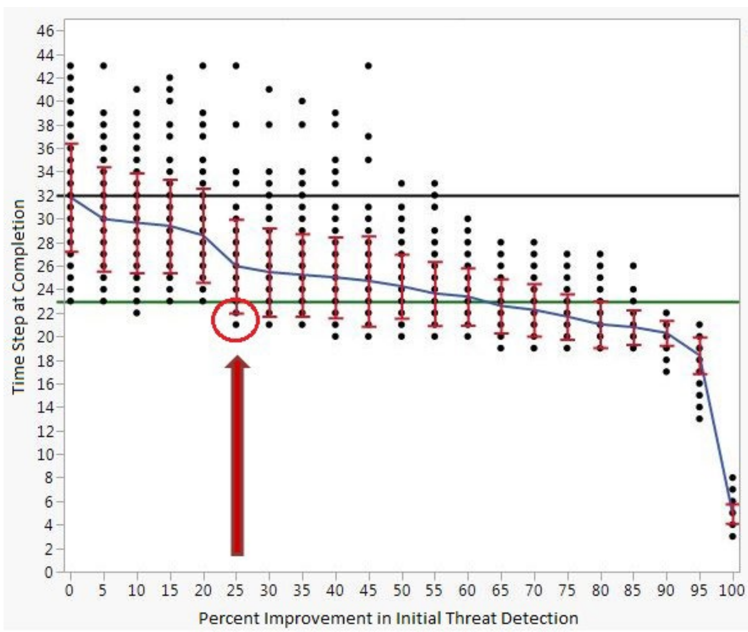


Figure 8. Distributions from the Adaptive SOP Enhancement Simulation Experiment

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 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 a crisis response that incorporates an adaptive, innovative methodology could yield a reasonable and significant benefit to the field of crisis response.

This simulation experiment is an exercise in counterfactual history intended to portray the prospective value of an adaptive crisis response. Of course, 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.[35] However, while these results are only hypothetical, they do effectively promote adaptability in crisis response by quantifying and visualizing their potential enhancements to the emergency response paradigm. When combined with the arguments for adaptive response presented in the case study, the article’s central hypothesis that success in complex disasters requires adaptability is supported persuasively.

The incorporation of adaptability prompts into the traditional SOP structure may help crisis professionals more effectively manage complex emergencies as they emerge. The SOP modifications make the expectation of change a core theme in every emergency response. Even more importantly, the prompts compel the emergency responder to adjust the operational plan to address 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.

The use of SOPs may be an immutable component of government procedures, even in complex scenarios when their contribution is suspect. However, the implementation of adaptive design proposals would modify the traditional SOP to help responders more effectively manage complex events. In short, the adaptive designs are simple improvements to the emergency response tool box, engineered to achieve quick and uncomplicated implementation in the field. These changes might help crisis professionals effectively apply critical thinking and adaptability in an evolving crisis, allowing them to better protect themselves and their communities.

Conclusion

When responding to an emergency, crisis professionals rely on their training, equipment, and experience, and act in accordance with SOPs. Ideally, the SOP checklist used ensures consistent and successful performance by correctly anticipating the events that will unfold within the operating environment and recommending appropriate actions. So long as the actual events adhere to the SOP’s predicted behavior, responders should make effective choices in the field. The Disaster Dilemma arises when an evolving crisis diverges from expectations and the SOP hampers effective response efforts by prescribing actions that are no longer appropriate in response to the emergent problem.

This research examined 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 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.

While the characteristics of modern crises have evolved, many of the SOPs used to manage them have not. Fortunately, certain fields within the emergency response paradigm have begun evolving in ways that reflect the adaptive doctrines espoused in this article. "Decision tree modeling" has begun to influence modern emergency response plans, promoting the expectation and mitigation of unexpected events.[36] A specific instance of adaptive crisis response in practice is the nascent *Incident Tactical Dispatcher (ITD)* role adopted by some emergency response agencies in the United States. The ITD provides remote support to a field team leader operating in an emergency environment, maintaining constant radio contact and performing a number of critical duties to include helping to identify and mitigate unexpected problems.[37] This emergency response function closely resembles the crisis co-pilot design recommendation and its capacity to promote adaptive response in emergency circumstances could revolutionize the concept of the 9-1-1 police dispatcher.

If traditional SOPs are too inflexible to impart effective direction in complex emergencies, modern disaster management needs a new approach. The 9-11 case study used in this research and simulation suggest that adaptive measures provide more effective solutions in complex environments. The simulation presented the hypothesis that the minimal integration of adaptive qualities into the response strategy can yield significant improvements in the outcome of a complex event. Finally, the proposed SOP design solutions address a practical methodology for integrating adaptive behavior and critical thinking into crisis response while allowing for the continued employment of SOP guidance in the emergency management arena. Modern crises demand a response that accounts for complexity in the environment. Implementing measures to integrate adaptability into emergency response may be a critical step in protecting our emergency responders and empowering them to better safeguard the public.

About the Authors

Shawn M. Harwood is a Supervisory Special Agent for U.S. Homeland Security Investigations (HSI) with over 20 years' law enforcement experience. He is currently posted as the HSI Attaché at the U.S. Consulate in Guangzhou, China. Prior to his tour in China, Mr. Harwood served as the HSI Headquarters Liaison to the Justice Department's Office of International Affairs, as an HSI Assistant Attaché at the U.S. Embassy in London, England, and as a Special Agent and Tactical Medic at the HSI Office of Investigations in Atlanta, Georgia. Mr. Harwood has also worked as a Border Patrol Agent in Brownsville, Texas and as an Economist in the Statistics of Income Division of the Internal Revenue Service. Mr. Harwood obtained undergraduate degrees in Economics and English Literature at the University of Virginia and earned a master's degree in Security Studies at the Naval Postgraduate School. He may be reached at Shawn.Harwood@ice.gov.

Dr. Wayne Porter, CAPT, USN (ret), is a Senior Lecturer in the Defense Analysis and Systems Engineering Departments of the Naval Postgraduate School, where he also serves as Co-Director of the CORE Lab and Director of the Littoral Operations Center. He holds a Ph.D in Information Sciences and two Masters of Science degrees – in Computer Science and Joint C4I Systems Technology - from the Naval Postgraduate School. Military duty included Japan, England, Italy, the Balkans, Bahrain (COMFIFTHFLT ACOS Intelligence and MOC Deputy of Operations in the Persian Gulf/East Africa), and three tours on the personal staff of ADM Mike

Mullen, including Special Assistant for Strategy to both the Chief of Naval Operations (N00Z) and Chairman of the Joint Chiefs. He subsequently served as Chair, Systemic Strategy and Complexity at Naval Postgraduate School in Monterey, California and retired from the Navy in July 2014 after 28 years of active service. Dr. Porter was hired as a faculty member at NPS in 2015 and in 2017 he provided systems analysis for the SECNAV's Strategic Readiness Review.
He may be reached at nwporter@nps.edu.

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