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THESIS

WHERE DO I START? DECISION MAKING IN COMPLEX NOVEL ENVIRONMENTS

by

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September 2010

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13. ABSTRACT (maximum 200 words)

Threats to our country have never been more real, nor had more potential to impact large populations of Americans. From the homeland defense perspective, some ideology-based groups have the ability and intention to attack the United States in ways that we as a nation have never imagined. As our world grows more complex and unpredictable, our first responders need tools to enable them to operate in this space.

This thesis focuses on how decisions are made in complex novel environments. Using Grounded Theory methodology, interviews were conducted with public safety personnel who had past experience managing incidents that matched the study criteria. Aspects of Complexity Theory and Recognition-Primed Decision Making were identified as core components.

Based on these findings, a descriptive process model was developed that modifies the existing Recognition-Primed Decision Making model in order to account for novel situations, in addition to those cases where the decision maker has previous experience. The Exploration and Exploitation Decision Making model (Ex^2DM) is based on actual practices by both law enforcement and fire-rescue professionals. With an understanding of the unique characteristics of complex environments and how decisions are made under these conditions, public safety personnel will be better prepared to manage complex incidents.

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WHERE DO I START?
DECISION MAKING IN COMPLEX NOVEL ENVIRONMENTS

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My son, Adam, was four years old when I began this journey. He has been very patient, waiting for me to finish my school work so I could come out and play. While writing this thesis, he sat beside me playing or drawing, doing his "school work" just like Mommy. He will start kindergarten the same month this thesis is finalized, starting his academic journey as I complete mine. This work is dedicated to him.

My husband, Robert, has been the strong rock of stability for the family these eighteen months and my journey would not have been possible without his love and support. I do not know if I can ever repay him for the many hours of being a single dad, running the family while I was away at school or locked in the office on the computer.

I would also like to thank my department for their support of innovation. The initial concept for this project came from conversations at work. We were discussing concerns for the young work force in our discipline and whether these new team members have everything they need to be successful. San Diego Fire-Rescue is constantly striving to improve. More than one book cited in this thesis was found on the bookshelves in offices around headquarters. Their knowledge of not only firefighting, but also leadership, made them some of my best references. I am grateful for their support of my academic goals and am honored to be a part of the organization.

To both my advisors, and the great professors at the Center for Homeland Defense and Security, I thank you for giving me the confidence to think big thoughts and question the world around me.

Finally, I would like to thank the men and women who gave their time for this project. Not everything we discussed was easy. Yet they were candid in their self-evaluations, especially the decisions they still struggle with. If you ask my son, Adam, what I do for a living, he will tell you, "My mommy helps the firefighters and the policemen." I do so proudly. This thesis is about complexity, and while I write about it, they live it. I only hope that this work helps them the next time they are faced with a difficult challenge.

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I. INTRODUCTION

A. PROBLEM STATEMENT

In the aftermath of the September 11th terrorist attacks in 2001 and Hurricane Katrina in 2005, management of large-scale complex incidents has come to the forefront of public debate (Thomas & Beckel, 2005) and has instigated organizational change at the federal level (Bea et al., 2006). While it is generally understood that managing such situations is not an easy task, the public expects first responders to be able to manage even the most complex incidents effectively.

According to the U.S. Department of Homeland Security (2008, pp. 2–24), complex incidents include a combination of factors that affect the ability to control an incident. Such factors can include:

- Community and responder safety
- Impacts to life, property, and the economy
- Potential hazardous materials
- Weather and other environmental influences
- Likelihood of cascading effects
- Potential crime scene
- Political sensitivity, external influences, and media relations
- Area involved, jurisdictional boundaries
- Availability of resources
- Potential to extend multiple operational periods

Multiple complicating factors pertaining to an incident (such as those listed above) increase the number of potential unknowns, creating a situation in which it is difficult to predict outcomes. This is the definition of complex in its most basic sense. For those working in complex circumstances, creating mental simulations of possible outcomes in any environment is difficult (Klein, 1998)—it is even more so without a

framework to organize the complexity. Ambiguity, time limits, and excessive noise all can act as stressors. While stress in and of itself does not cause low-quality decision making,[1] stressors distract the decision maker, inhibiting the ability to gather and process information (Klein, 1998).

And yet, under these conditions, first responders are responsible for comprehending the incident environment and quickly determining the required steps to stabilize the situation. As Boin et al. notes:

> In a dynamic and volatile situation, windows of opportunity to intervene are often fleeting. Decisions as to whether and how to act or not must be made rapidly or the possibility to affect the course of events may be lost. (2005, p. 29)

First responders working under these conditions must maintain mental functionality, including understanding the context of the incident, what problems must be solved, and what actions to take (Weick, 1995). Even when experience offers no parallels of reference, and previously prepared plans and procedures do not seem to apply, the men and women responsible for managing complex incidents must find a way to operate within the chaos.

B. RESEARCH FOCUS

This research focuses on how decisions are made in the realm of the complex and novel. For the purposes of this work, a system is complex "when there are strong interactions among its elements, so that current events heavily influence the probabilities of many kinds of later events" (Axelrod & Cohen, 2000, p. 7). A public safety incident is considered a complex system when there are multiple mitigating factors with the potential to interact in many ways, making it difficult to predict a likely outcome. Relationships between the complicating factors may be discernible in hindsight, but not during or before the incident.

[1] High quality decisions are defined as satisfying procedural criteria, and have a better chance than others of obtaining the decision makers' objectives. Low quality decision making would then be the opposite, decisions that are less likely to obtain the decision makers' objectives.

Examples of complexity can range from a single-person rescue to the 2004 train bombings in Madrid. In both cases, there are many factors that affect incident stabilization. For a rescue, mitigating factors may be where the person is stranded, or if it is difficult for rescuers to gain access. In the Madrid bombing, incident stabilization was challenged by the fact that it occurred on a mass transit system during rush hour, ensuring a large number of victims (Gardiner & Phillips, 2005). In both cases, there is no clear predictable outcome, especially during the initial incident response. The rescue victim may be successfully extracted or may die due to delays in getting access to the site. For Madrid, it was unclear at the time exactly how many bombs there were, and if more would be detonated while the rescue response was underway. It is not the scale of the incident that makes it complex, it is the potential for unexpected outcomes.

For an incident to be deemed "novel" in this research, the most impactful circumstances of the incident, as defined by the primary decision maker for the incident (commonly called the incident commander) were neither previously encountered during an actual incident nor practiced or studied in training. Opinions vary widely on the concept of novelty, especially when discussing incident command. Some would say that every incident is unique with no two the same; there are always differences in the circumstances that have the potential to change outcomes. In considering two residential fires, the fires may have started in different parts of the home, have different fuels in the house affecting fire behavior, etc. In some cases, it may be appropriate to knock a hole in the roof, in others it may not. From this perspective, each incident must be considered individually when determining appropriate tactics.

Another school of thought is that novel incidents are extremely rare; that in fact, there are very few circumstances that are truly unique. An example from law enforcement is a routine traffic stop. While the particulars may vary, the policies and procedures of how to approach the vehicle and engage its passengers are the same. As long as a person is trained adequately to the standardized procedures based on the most common scenarios, they are unlikely to encounter a situation where some form of training and procedures could not be applied.

These two points of view represent two extreme ends of a spectrum, with individual opinions varying along the spectrum. Either way, it is the opinion of the person experiencing the incident that matters. If he believes the situation to be significantly different than previous experience, he may have troubles applying previous knowledge to the situation in order to determine how best to proceed. Also, regardless of one's personal opinions of novelty, standardized procedures and learned tactics are important. Even in a novel circumstance, it may be appropriate to apply them. However, an incident commander must be able to incorporate new ideas for those circumstances where previous tactics are not appropriate.

As part of this research study, inductive methods will be used to gain a better understanding of how the decision making process is affected under these circumstances. The intended result of this research is the development of a process model that describes how decisions are made when complex novel situations occur.

C. RESEARCH QUESTION

What is the process for making decisions in complex novel situations?

D. ARGUMENT

Threats to our country have never been more real, nor had more potential to impact large populations of Americans. From the homeland defense perspective, some ideology-based groups have the ability and intention to attack the United States in ways that we as a nation have never imagined. As our world grows more complex and unpredictable, our first responders need tools to enable them to operate in this space.

For incident commanders who do not have direct experience, and yet must operate under the circumstance of extreme complexity, previous theories of decision making have significant weaknesses. Analytical systematic processing of information takes too much time to find the best solution. Naturalistic decision making using the Recognition-Primed Decision (RPD) model fails in theory if there is a lack of experience or when encountering a completely novel scenario.

While some may assert there is never a situation where an experienced decision maker cannot find a past experience to draw upon, this claim fails to recognize the very

real possibility that the most experienced first responder on scene may be relatively new to the occupation and still be required to manage the incident until a more experienced person takes command.

A second counter argument to this challenge is the evolving threat of terrorism, with its potential to attack in ways we have never encountered before. Many of our nation's first responders have little or no experience managing incidents while under attack, when the potential for novel incidents is the greatest. The threat of an unknown and unpredictable adversary can incite panic in both the responder and the public they are charged with protecting, creating an environment never imagined, let alone experienced or planned for.

"Sensemaking is tested to the extreme when people encounter an event whose occurrence is so implausible that they hesitate to report it for fear they will not be believed" (Weick, 1995, p. 1). Inability to comprehend a complex situation can cause uncertainty in the decision maker. This occurs when key pieces of information are missing, unreliable, ambiguous, inconsistent, or too complex to interpret. The result will be a reluctance to act (Klein, 1998). In complex incidents, time is a key factor to regaining control of the situation, and reluctance to act wastes valuable time. One might ask, is just making sense of the situation enough to overcome this reluctance? If first responders can observe the environment and orient themselves, they have overcome the major obstacle of making a decision: overload.

Effective incident commanders have been found to have three common qualities (McLennon, Holgate, & Wearing):

1. Work in a manner not to exceed their own working memory capacity
2. Monitor and regulate their emotions and arousal level
3. Take into consideration subordinate's working memory capacity

Essentially, they are aware of and able to manage overload in themselves and others, ensuring that the incident response team is operating at maximum mental capacity. First responders want to find solutions and manage the situation; this ability is limited due to excess arousal.

A lack of previous experience with a situation does not necessarily lead to reluctance to act. If the first responder can detect patterns and find meaning in the complexity without relying completely on experience,[2] then a singular systematic approach to evaluating options could be utilized to evaluate potential actions and make a decision that satisfies the conditions quickly. The benefit of this concept is that it incorporates a naturalistic decision making model, developed by studying first responders in the field, without being held to the limitation of experience. The decision-making process for the incident commander does not change; the commander simply has additional knowledge to draw upon.

E. SIGNIFICANCE OF RESEARCH

A considerable amount of research has been conducted regarding the ability to process information and make decisions. Where the research falls short, however, is in considering situations so complex commanders might find themselves lacking the ability to comprehend the environment in which they are working. This is worrisome, especially as the world becomes more interdependent, increasing the potential for any incident to become complex.

Fifty years ago, a hurricane hitting the gulf coast would have been a tragedy in lost lives and damaged property; it is now an incident of national significance.[3] In today's world, people are connected in ways without precedence. With our global economy, a storm's impact to oil fields in the golf can have a ripple effect impacting all Americans. The technology revolution has led to a greater connectedness by increasing the speed of accomplishing tasks. Combined, this translates to more people impacted by a single event, realizing its effects almost immediately.

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[2] All first responders deployed in the field have some level of experience and training. It is the author's assertion that in certain novel scenarios, the training or experience may not be directly applicable or comprehensive enough to fully address, develop a response, and predict outcomes solely on experience.

3 An Incident of National Significance (INS) is an actual or potential high-impact event that requires robust coordination of the federal response system in order to save lives and minimize damage, and provides the basis for long-term community and economic recovery. The Secretary of Homeland Security, in consultation with other departments and agencies, and the White House, as appropriate, declares Incidents of National Significance. Note that as of January 2008, this declaration has been eliminated.

From a homeland defense perspective, asymmetrical threats are real and have already led to attacks to our nation in ways Americans have never imagined. In complex situations, the training, experience, and cognitive methods currently used by first responders to manage an incident may not apply. This research addresses this potential problem by building a descriptive model of how decisions are made in novel scenarios. Emergency managers and fire, police, and EMS command staff can all benefit directly from understanding the decision making process. As our world grows more complex and unpredictable, our first responders need tools that enable them to operate in this space.

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II. LITERATURE REVIEW

Decisions are made every day. We decide what to eat, what to wear, and who we should vote for in the next election. Some decisions we ponder and look at all options to find the very best one. Other times, we do what is called satisficing,[4] which is searching for the first good option that will work, even if it is not the very best option available. How do we determine the appropriate process? Often times, it is influenced by the context of the decision maker. Are they in a hurry and need to make a decision fast, or do they have time to really study the issue? In looking at the literature on this topic, there are significant gaps in the literature regarding the "situational impacts of actual decision making" (O'Reilly, 1980, p. 687). While this comment was made 30 years ago, a review of the literature shows a continued gap, especially pertaining to complex novel environments.

In today's environment of large-scale natural disasters and terrorist threats, even the most seasoned incident commander has the potential to become overwhelmed and experience stress. According to Boin et al., stress entails a relationship between task load and the coping capacity of the individual or collective. Stress need not necessarily degrade performance, cognitive or otherwise, if the task load is balanced with a high degree of coping capacity.

Boin et al. found that under stress, an individual's abilities are impacted in the following ways:

- Individuals focus on the short term
- Fall back to old behavioral patterns
- Narrow and deepen span of attention
- Rely on stereotypes or lapse into fantasies
- Easily irritable

[4] This term is credited to H.A. Simon's *Administrative Behavior* (1976) but was discussed in Irving Janis' *Crucial Decisions*, p. 37.

Evaluation of solutions to improve situational assessments in complex environments must assume the decision maker is operating under stress, and take into consideration these factors. To be clear, stress does not necessarily result in faulty decision making. It may, however, limit the information one is able to consider (Klein, 1998). One common impact of stress is overload: the inability to process information within a defined timescale. Overload can manifest in multiple ways, including extreme visual clarity, tunnel vision, diminished sound, and the sense that time is slowing down. The human brain drastically limits the amount of information we have to deal with (Gladwell, 2005). It is a situation where the inability to process information leads to inferior decisions due to lack of pertinent information. While one cannot ignore the body's default responses to stress, it is important to find ways to mitigate this stress for the incident commander.

A common theme discussed in the literature is the role of the unconscious in the task of orienting. When considering our mind as a well-designed efficient system, the unconscious is actively monitoring and assessing the world outside, often without us even realizing it is doing so (Wilson, 2002). Wilson asserts it is possible to shape and change our unconscious behavior through conscious self awareness and purposeful changes in behavior to train the unconscious. Building on this concept, Klein suggests fire commanders have a rich fantasy life where they mentally simulate potential attacks and decide how they would combat them (Weick, 1995). This practice of imaging a situation and how they would manage it allows commanders to grow experience that will be stored in the unconscious without having to encounter an actual incident. Gladwell agrees, stating "spontaneity isn't random. … How good people's decisions are under the fast-moving, high-stress conditions of rapid cognition is a function of training rules, and rehearsal" (Gladwell, 2005, p. 114).

Another key inhibitor to orientation or sensemaking in complex environments is uncertainty. Uncertainty is doubt that threatens to block action. This doubt can manifest when key pieces of information are missing, unreliable, ambiguous, or too complex to interpret. As a result, the decision maker will be hesitant to act (Klein, 1998). It is this hesitancy that incident commanders strive to avoid. Weick asserts that in order to manage

the unexpected, one must remain mindful. He defines this as "striving to maintain an underlying style of mental functioning that is distinguished by continuous updating and deepening of increasingly plausible interpretations of what the context is, what problems define it, and what remedies it contains" (Weick & Sutcliffe, 2001, p. 18). Understanding the environment around us, making sense of the information available is critical to decision making. If incident commanders are not mindful, or able to comprehend external inputs from the incident environment and place them in context, then their ability to make a determination based on their judgment is compromised.

One school of thought regarding decision-making processes was that people made decisions using a rational analytical process of decision making,[5] gathering multiple options for action systematically, simultaneously evaluating risks associated with each option, and selecting the least risky option. Janis, however, disrupted this body of knowledge stating, "the rational actor model does not stand up very well as a descriptive theory" due to cognitive constraints including lack of time, lack of expertise, and lack of resources (1989, p. 13). Instead, Janis stated that the appropriateness of simplistic decision rules is situation specific.

Later, in the mid-1990s, Gary Klein built upon Janis' work and developed a model of naturalistic decision making where decision makers use past experience to make decisions in field settings, called Recognition-Primed Decision (RPD) making. According to Klein, for experienced decision makers, certain situations lend themselves for naturalist decision making, including:

- Time Pressure
- High Stakes
- Experienced decision makers
- Inadequate information
- Ill-defined goals
- Poorly defined procedures

[5] See Chapter V, Figure 8, for a diagram of the Rational Analytical decision-making process.

- Cue learning
- Context
- Dynamic conditions
- Team coordination

Under these conditions, decision makers often use a singular evaluation approach. A single option is selected, often based on past experience, evaluated as plausible, and selected if it is determined to potentially satisfy the conditions. Options are developed and evaluated one at a time. If the first option does not satisfy the context of the problem, then another option is evaluated, one by one, until a satisfactory solution is found. This method was supported by research done at this same time by Weick, who studied highly reliable organizations, including fire departments, and found commanders use their past experiences and then visually model potential outcomes (Weick & Sutcliffe, 2001). Both Janis and Klein believe naturalistic decision making occurs due to time constraints and a lack of complete information. The rational analytical model is rendered impossible, because there simply is not enough time or information to develop and evaluate a set of options. Under these constraints, decisions are based on satisficing, not optimizing. Figure 1 shows the how the differences in context determine the types of decision making used.

A key component of the naturalistic process is how an individual makes sense of the situation. Klein proposes RPD, where a person uses experience to recognize patterns and quickly develop satisfactory solutions.[6] Decision makers draw on memories of past incidents, solutions tested, and final outcomes. They imagine how similar tactics might be applied to the current scenario. This theory fails in a scenario where lack of experience or incident complexity leaves the decision maker unable to draw on past experiences in order to make sense of the situation.

[6] See Chapter V, Figure 9, for a diagram of the RPD process.

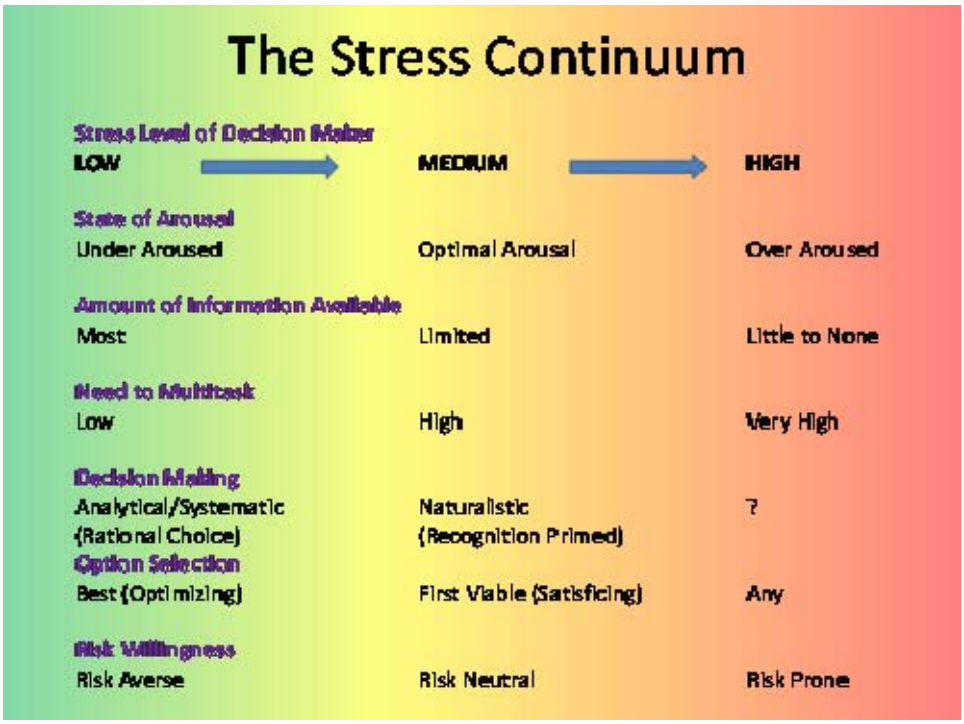

Figure 1. Differences in Decision Making Based on Stress and Time Constraints

Boin et al. state that "if the situation is radically different from those stored in memory, a somewhat different kind of sense-making process will be necessary" (2005, p. 36). Boin et al. never provide a definition or description of sensemaking in this complex scenario, representing a gap in the knowledge concerning this topic. Klein recommends novices or decision makers in extremely complex situations use the systematic rational analytical process (Klein, 1998). However, this solution does not apply even with applicable past experience. If rational analytical decision making is too slow for complex situations, how can it possibly be viable for extremely complex environments or less experienced personnel?

In reviewing the literature, how one orients to their surroundings is of critical importance in the study of decision making in novel situations. Orientation is the independent variable upon which all other steps of the decision-making process depend. It is also the most subjective since orientation includes personal experience, culture, rules, and situation specific data from the incident environment. In order to maximize the orientation process, it is important that the incident commander is not experiencing

overload and is instead mindful. When making decisions, naturalistic decision-making models using singular option evaluation are preferred over rational analytical methods. When subjected to stress and time pressure, it is better to satisfy rather than optimize. As shown in the literature, this poses a problem if the situation is novel for the incident commander. A gap in the knowledge exists as to whether one can use naturalistic decision-making methods without pertinent experience to recognize patterns of expected behavior and associate with past outcomes.

III. INDUCTIVE PROCESS AND GROUNDED THEORY

The result sought at the culmination of this project is the development of a process model to describe how decisions are made in complex and novel situations. To best achieve this goal, the qualitative research method of grounded theory was selected. Grounded theory was developed by Glauser and Straus in 1967 as a formal method meant to be an opposite of the logico-deductive methods prominent in social sciences at that time (Glauser & Strauss, 1967). Instead of verifying a theory, grounded theory discovers new theories through the study of data and inductive analysis. The process of performing grounded theory is "iterative, messy, and ambiguity-laden" (Locke, 2001, p. 50) but revolves around the following steps:

1. Sampling
2. Creating and organizing conceptual categories
3. Reducing to focus on relevant and robust findings based on achieving theoretical saturation
4. Development of a substantive theoretical model in the form of a process model

Following the grounded theory standard, the selection of subjects for this research was far from random. Instead, public safety professionals were selected based on whether they had held a position of responsibility in the past where they were responsible for making decisions during an active incident that could be typed as both complex and novel. Coding, comparison analysis, and the drafting of research notes regarding data gathered from the research subjects were all used to identify key characteristics of the decision-making process. Figure 2 shows an example of how a comment made during the interview process is categorized and reduced, moving from a quote made by the research subject, through the multiple levels of coding, to classification as support for a concept.

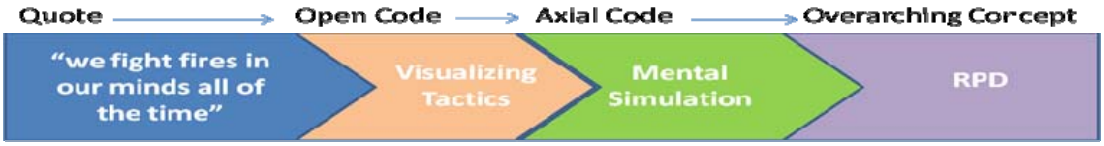

Figure 2. Example of the Coding Process

Research was then conducted comparing existing literature on decision making and complexity theory to key concepts identified during the coding process. Whether the concepts mesh or contrast with existing theories, it is still important for the researcher to understand how their work fits into existing bodies of knowledge. This study of prominent concepts, and the ensuing comparisons, was used to further refine analysis of the data collected. The result is a model based on actual experiences by decision makers in the field, supported by academic bodies of knowledge.

The proposed model developed through this process was then analyzed for usefulness and credibility. Finally, the document concludes with a discussion of how the proposed hypothesis may be practically applied, an analysis of its limitations, and suggestions for future research.

A. ROLE OF THE RESEARCHER IN GROUNDED THEORY

In Grounded Theory, the researcher plays a direct role in shaping the research as a whole. Unlike other methodologies, where the researcher is purposefully isolated from the research so as not to affect results with personal biases, grounded theory accepts the background and perspective of the researcher as an integral part of the research process.

As a civilian employee of police and fire agencies in the San Diego area over the past 12 years, the author has had the opportunity work with many of the men and women who manage complex incidents in San Diego County. This contact has occurred during incidents, exercises, day-to-day operations, or as part of regional committees. Because the author lives and works in the area from where the majority of the research subjects were selected, she had an indirect role in or knowledge of some of the incidents discussed during the interview process. These biases directly shape this research project. To partially mitigate this bias, the coding process was validated with direct quotes and

examples from the interviews, ensuring the raw data supported the general themes identified as the data was progressively reduced to general themes. If the themes could not be supported by direct quote or example, they were eliminated from the sample set.

B. INTERVIEW PROCESS

Selecting samples to study in grounded theory is not random. Instead, the researcher is encouraged to actively search for data that will "best support the development of the theoretical framework" (Locke, 2001, p. 55). Interviews were conducted with personnel in the policing and fire-rescue disciplines. Incidents discussed were selected by the interviewees themselves. Prior to the interview, they were asked to identify one or two incidents in their past experience that they considered complex and novel and to be prepared to talk through those experiences. Advanced notification of the topic allowed the interviewees to identify their incidents and reflect on the experiences in preparation for the interview discussions.

Because the interviewer did not assist in the selection of the incidents discussed, the terms "novel" and "complex" were defined by the research subjects themselves. As noted in Chapter I, there are varying opinions regarding what constitutes novelty in a public safety incident, and this was reflected in the incidents selected by the research subjects. While all incidents discussed were linked to the subjects trained discipline, each example discussed had some feature that made it unlike any specific training the subject had received and was considered sufficiently complex to qualify, in their minds, as applicable to the research. The very fact that the commander who experienced the incident believed it was novel and complex made the experience pertinent to this study.

1. Selection of Research Subjects

Nine public safety professionals were identified through known contacts of the researcher in San Diego County. All, with the exception of one, work within San Diego County. Research subjects were solicited for this project in two ways: solicitation through a regional public safety working group, and direct requests for interviews. At the regional meeting, the research topic was presented to the entire committee and interested parties were asked to contact the researcher if they wanted to participate. Additionally,

some were selected specifically by the researcher based on personal knowledge of their career performance managing complex incidents. Of the nine volunteer research subjects, two asked to remain anonymous and will not be identified by name or agency.

2. Conducting Interviews

Eight of the nine interviews were conducted in person. The ninth interview was conducted over the telephone. In all cases, the interviews were recorded with the permission of the research subjects and transcribed. Interviewees were asked to sign an informed consent form, which outlined the basic topic of the research, and were asked in advance to identify one or two incidents that they considered complex and novel prior to the interview. While the researcher had a predeveloped list of interview questions, the interviews were conducted in a free-form format, with the interview questions used only to ensure that topics of interest were covered.

Following each interview, written notes were compiled to document ideas resulting from the interview. Similarities and differences from previous interviews were of particular interest. These written notes from the interviews were guided by the research question, existing knowledge of the researcher gathered while conducting the initial literature review, and of course, the researcher's bias as discussed previously in this chapter. These notes constituted the initial step in analyzing the interview data to begin to see patterns, which would be further refined through the coding process.

C. CODING AND ANALYSIS OF INTERVIEWS

1. Open Coding

Open coding was used to identify common themes in the data collected. It is the process where the researcher searches transcripts, field notes, and other texts for meaning units, which they label. These labels are the codes (Gilgun, 2004). The coding process is purely subjective, decided upon by the researcher based on the area of interest for the research as well as the researcher's personal biases. In this case, the researcher wrote brief notes in the margins of the interview transcripts and field notes with ideas and

concepts she found pertinent to the research focus. A collection of 266 codes were developed during this process (see Appendix A for the complete list).

2. Axial Coding

Using the list of codes developed in the step above, the codes were next analyzed for common themes. The themes were generated by isolating the codes from the initial transcripts and field notes, and looking for ways to organize the data. "Induction is the movement from data to concepts" (Gilgun, 2004). In examining the initial codes, 33 themes were determined by the researcher (see Appendix B for the complete list). Once the 33 themes were created, the next step was to see how many codes were related to each theme in order to further categorize the themes based on prevalence in the original data. Finally, the 33 themes were further reduced to two relevant concepts.

D. RESEARCH BASED ON TOPICS IDENTIFIED DURING INTERVIEWS

The third step in Grounded Theory research is the reduction of the focus to relevant and robust findings. The two primary concepts identified during the interview coding process, RPD and Complexity Theory, were selected by the researcher as the most pertinent findings from the interview data. Grounded Theory research emphasizes the need to gather data not only from real-life examples, but also to remain firmly grounded in the existing body of academic knowledge. In order to better understand both RPD and Complexity Theory, a literature review focused on these two topics was conducted.

E. DEVELOPMENT AND EVALUATION OF THE MODEL

"Interpretive paradigms are distinguished by an interest in understanding the world of lived experience from the point of view of those who lived it" (Glauser & Strauss, 1967, p. 8). The final step in this study was the creation of a process model based on actual experience and supported by existing academic knowledge. The model was then evaluated against both the research question, and Glauser and Strauss' criteria for usefulness of new ideas developed through the inductive Grounded Theory methodology:

- Enable prediction and explanation of behavior
- Be useful in theoretical advancement in the subject

- Be useful in practical solutions
- Provide perspective on behavior
- Guide and provide style for more research

Just as the research methodology incorporated both real-life experiences and academic research, the end result should also benefit both real-life practitioners, as well as advance overall academic knowledge in the subject matter.

IV. ANALYSIS AND FINDINGS

A. INCIDENTS DISCUSSED DURING THE INTERVIEW PROCESS

The following is a brief overview of each of the incidents discussed during the interview process.

1. Lieutenant Tom Leonard, Chula Vista Police Department (Retired)

Lt Leonard discussed two incidents, both associated with his time as a police officer with the Chula Vista Police Department. In the first incident, Lt Leonard was responding to a call for service at a second-story apartment building where a male was reportedly high on drugs and going crazy in the house. Upon arrival, he found the male standing in broken glass in the sill of a bay window. The solution finally selected was to shoot the man with water out of the window and into the apartment using a fire hose from an engine staged at the scene for medical aid.[7] This incident was considered novel to Lt Leonard, because he had never before (or any time again in his career, for that matter) used a fire hose to control a situation. It was complex because the man was on drugs and acting irrational, and therefore, it was difficult to predict his actions. Tactics that may have worked on someone not in this mental state could not be applied in this situation because it was impossible to predict how the man would react. There was a high likelihood that this man would be injured or even killed if the wrong tactic was chosen, which added stress to the situation.

Lt Leonard discussed a second incident during the interviews where he and two other individuals were asked to break into a house to check on a diabetic person who might be in trouble. They were checking the apartment, when the man jumped out at them in a crazed state, brandishing a shot gun with his finger on the trigger. Lt Leonard was approximately 12 feet from the man and directly in his line of sight. While Lt Leonard had trained in defense classes, he had never been in a situation before where he

[7] See Chapter V, Section D, for a more detailed study of this incident.

had to instinctively apply those tactics and therefore, he had difficulty predicting how the incident would end, though he realized that his death was a possible outcome.

2. Officer Lance Dormann, San Diego Police Department

Officer Dormann decided to discuss an incident where he was a covering officer serving a warrant at a person's house. Three officers (including him) were let into the home by family members of the person of interest. They were then shown to a bedroom where the man was sleeping. All three officers entered the room and proceeded to try to wake the person and arrest him. What Officer Dormann was not aware of at the time was that while they were in the bedroom, the family members had locked the door, trapping them inside the house. When the person being served became uncooperative, the family members blocked the officers into the room, and refused to let the police officers out of the room. Officer Dormann considered and even tried different tactics to de-escalate the situation—to no avail—and finally had to call for backup. Responding officers had to break a window to get into the home and help the officers trapped inside.

This situation was novel to Officer Dormann, who had never experienced being trapped while on the job. It was a complex situation mostly because the officers failed to realize the threats of the family members who let them into the home, but then proceeded to trap them inside.

3. Officer Sandi Lehan-Nichols, San Diego Police Department (Retired)

Officer Lehan-Nichols discussed two incidents during the interview. The first incident concerned a call for service to a residence where a woman was in a bathroom miscarrying a baby. As the only female officer on scene before the paramedics arrived, Officer Lehan-Nichols was made responsible for taking care of the woman until help could arrive. Though Officer Lehan-Nichols is a mother of three, she had never before been responsible for caring for a pregnant woman, especially one that was in distress as this woman was. "It was one of those situations you are not supposed to ever see," she said. The situation was complex, with two lives at stake and the lack of information about what was really happening. There was extreme pressure to keep both mother and baby safe until help could arrive.

The second incident was a response to a vehicle accident where the victim was a 2-year-old child who had been hit by large sports utility vehicle that was backing out of a driveway. What made this incident both novel and complex for Officer Lehan-Nichols was that the victim was such a young child. This made it difficult for her to disassociate her feelings and remain mindful. Language was also a complicating factor because the victim's family was hysterical and speaking Spanish, which Officer Lehan-Nichols had difficulty understanding. Without a clear understanding of what happened, it was challenging to determine how best to help the child who was still alive at the time, but later died at the hospital.

4. Anonymous Police Officer

The fourth interview was with a police officer confronted with a mob after trying to make an arrest on the beach during a crowded holiday weekend. With the hot summer sun, alcohol consumption, and a heightened police presence, the crowd became incensed by the arrest and quickly turned violent. Even though the officer had worked at the beach before the day of the incident, he had never encountered a situation like this one where crowd control became such an issue that the officer felt unsafe. This example qualifies as complex, but may not meet the standard of novelty defined in Chapter I.[8] Specific details regarding the case and the officer that participated in the interview have been withheld at the officer's request. However, all aspects of the interview were included in the coding process.

5. Anonymous Fire Chief

In October 2003, San Diego County experienced four simultaneous fires, the largest of which was called the Cedar Fire and burned 273,246 acres. The Cedar fire alone was second-largest fire in California history[9] (Keely, Fotheringham, & Moritz,

[8] As noted in Chapter I, the impression of novelty is subjective. Each incident described by the research subjects was selected because they considered the situation to be novel. However, this incident and others noted later in the chapter does not qualify as novel based on the definition used for this thesis. Incidents in the category of complex, but not necessarily novel, were included in the coding process.

[9] The largest fire in California history occurred in Santiago Canyon in 1889, burning approximately 300,000 acres.

2004). No firefighter working on that incident had ever experienced a fire of that magnitude. The fire burned simultaneously with 15 other fires throughout the state, burning 742,000 acres in one week and taxing limited resources. The Cedar fire was also particularly complex because it passed through multiple wildland areas into urban neighborhoods, necessitating coordinated evacuations and threatening a record number of structures. As one of the hundreds of firefighters working this incident, the chief spoke about his experiences as a captain during the 2003 fires. His interview covered five days of experiences and decisions made as he commanded groups of firefighters in several parts of San Diego County. Because all professional firefighters are trained in wildland fire tactics, this incident is considered complex, but not novel. Due to the extreme loss caused by this fire, the chief has asked that his comments remain anonymous and that certain particulars of his interview not be detailed. All aspects of the interview were included in the coding process.

6. Assistant Chief Brian Fennessy, San Diego Fire-Rescue

Chief Fennessy chose to speak about his experiences as the City of San Diego's Incident Commander and Operations Section Manager during the 2007 Fire Complex that occurred in San Diego County. The 2007 fires exceeded the 2003 fires that ravaged San Diego County in both intensity and duration, if not in total acreage (County of San Diego, 2008). While Chief Fennessy had over 30 years of firefighting experience, this was his first major fire complex where he served as Incident Commander for part of the incident duration, even though he was junior to many of the chiefs he was leading. There was extreme political and public pressure for the city to perform better than it had during the Cedar Fire in 2003. This pressure to perform, combined with complex wind-driven fire behavior that caused smaller fires to join into larger and faster moving fires, made this incident complex for Chief Fennessy, but not necessarily novel.

7. Assistant Chief Jeff Carle, San Diego Fire-Rescue

Chief Carle recalled a tanker fire incident. A tanker truck full of fuel had overturned on a major San Diego city street. One of the two tanks was leaking fuel and had caught on fire. What made this incident especially complex (but not necessarily

novel) was the fact that burning fuel was leaking into a highly sensitive watershed nearby. Adding water to the flames was furthering the contamination. A firefighting mission quickly became a hazardous materials incident due to the unique combination of complicating factors.

8. Battalion Chief Tom Gardner (Retired), CAL FIRE

Chief Gardner chose to speak about two incidents that occurred during his career. The first was one of his fires as a young captain, when a fire line broke and his crew was threatened. The situation was made more complex because the crew did not have a radio and did not realize that they were in danger. Chief Gardner had to figure out how notify his crew of the unsafe conditions as well as find a way to help get them safe.

The second incident Chief Gardner chose to talk about during the interviews occurred during the 2007 fire complex (the same fires Chief Fennessy discussed). Chief Gardner focused on a specific tragedy that occurred on the first day of the fires, when an engine was burned over with the fire crew trapped inside. Chief Gardner was in the state's San Diego Emergency Coordination Center, which received the radio distress call from the trapped crew. Any time a firefighter is trapped by fire, it is a traumatic experience for everyone listening. Chief Gardner had the responsibility of identifying the crew in danger, where they were located, and how to get resources to the scene to rescue them. This difficult job was complicated by the fact that the person on the radio identified themselves as belonging to a crew that wasn't assigned to the fire.[10] Chief Gardner had to find a way to identify the engine in distress without using their primary source of communications, the radio.[11] "No one ever told me what to do when somebody got burned over and the policy book just had a list of phone numbers you are supposed to call."

[10] The firefighter was a cover person that day working on an engine that was not her normal assignment. When broadcasting her distress signal, she accidentally identified her normal engine assignment instead of the temporary assignment she was working on that day.

[11] Because of the close personal and often familial relationships within the fire service, Chief Gardner did not want to broadcast roll call information or the name of the person in distress over the radio for fear that information would cause undue stress on those who knew the person.

9. Assistant Chief David Downey, Miami-Dade Fire Rescue

Chief Downey discussed his time leading an Urban Search and Rescue (US&R) team in Haiti in January 2010 as a Task Force Leader. While all task force leaders in the federal system have extensive experience and training, Haiti was different. "This was unlike any disasters domestically or internationally in the sense that there was far more potential for live saves, something we haven't experienced in the US&R system since its inception." Because of the scale of the destruction in the structures in Haiti, there were some circumstances where people were found but not able to be extracted. This also increased the complexity of the incident. The specific incident that Chief Downey discussed was a search for a live person. He decided to stop the search after several hours, without successfully locating and extracting the person.

B. CONCEPTUAL CATEGORIES DISCOVERED

While each individual event discussed during the interviews offers valuable examples of actual decision making under the pressures of an active incident, coding the interviews and research notes provided additional insight into the decision-making process. Through a multi-step process of indentifying relevant quotes from the interviews, and then refining the quotes into codes, themes, and finally, concepts, patterns and predominate themes were detected, which may not have been noted simply by reading through the interview transcripts.

Each interview, and the associated research notes, was analyzed line by line using an open coding process. A total of 266 codes were identified and were further analyzed to reveal 33 general themes (see Table 1). Figure 3 shows the breakdown of the themes by the number of times each theme was found in the open coding process (See Appendix A for a complete list of codes and themes generated).

Theme	Theme Description
Control of the Situation	The ability (or lack of) to direct or determine incident behavior.
Control of Arousal	The ability (or lack of) to maintain psychological and physiological activity during an incident.
Open to the Environment	Able and willing to receive and process inputs about the incident environment.
Active Role in the Process	Purposefully selecting to have an active rather than passive function in the decisions pertaining to the incident.
Mental Simulation	Ability to imagine the outcome of a decision.
Collective Problem Solving	Decision making involving inputs from more than one source.
Perspective	A choice of reference to sense, categorize, compare.
Information	A collection of facts.
Trust	To have confidence or faith in.
Comfort in Unknown Situations	A feeling of freedom or comfort when confronted with an experience or situation where there is a lack of facts or past frame of reference.

Table 1. Definition of Themes

These ten themes constitute 72% of the codes identified, and were present in both police and fire examples.

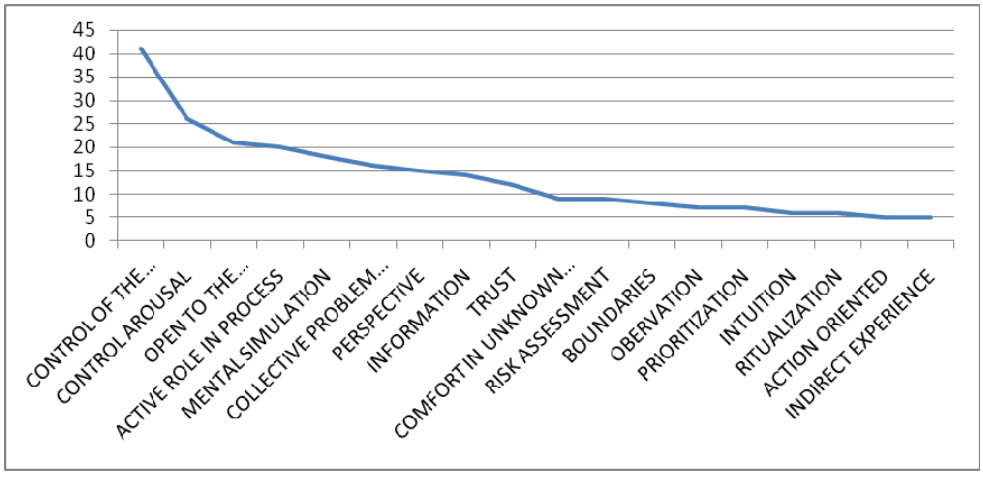

Figure 3. Common Themes by Occurrence

C. DISCUSSION OF MOST COMMON THEMES IDENTIFIED DURING CODING ANALYSIS

1. Control the Situation

Control of the situation was, by far, the most prominent theme during all of the interviews. One police officer noted that differences between controlling specific people and controlling a larger crowd. Crowds were by far more difficult to control and had the ability to change the dynamics of an incident very quickly and unexpectedly. A fire chief discussing a major fire in San Diego's history noted, "We weren't going to put it out. I knew that. The weather was going to dictate what this fire was going to do." This chief decided to focus on individual opportunities to save people and property when they presented themselves, instead of trying to stop a fire that was clearly out of control and would run its course regardless of tactics taken.

In almost every interview, there were examples of factors that could be controlled by the decision maker and those that could not. A common tactic was to isolate portions of the incident and inhibit interactions or chain reactions that could further disrupt the situation. Police officers would try to isolate their people of interest from other people not directly related to the incident who could change the incident circumstances. Fire commanders looked for natural barriers as ways to channel a fire into a more controllable path. Interviews from both disciplines gave examples of controlling the incident just enough to get it to a stage where they could apply past experience and known successful tactics.

2. Control of Arousal

Officer Lehan-Nichols noted how a lack of information or incorrect data can inhibit control of arousal. In her example, she was responding to a pedestrian hit by a car, which at first seemed to be a routine call for service. The information that was lacking, making the example complex and novel for her, was that it was a 2-year-old child and she would not have time to prepare herself emotionally for what she was about to see.

> If I had known that it was a two-year-old girl who got run over by a car, I could have prepared, disassociated myself from the scene. Not seen likenesses to my life.

Other interviewees discussed their coping mechanisms and the importance of controlling their emotions while working an active incident. Some would walk away for a moment and have a conversation with God, some turned themselves away from a visual sight that might upset them, others stressed the need to just keep focused on the task at hand until a appropriate time to digest the gravity of the situation. "It is the citizen's emergency. It is our job, we owe it to them, to be professional, remain calm, and do the very best we can for the maximum number of people that we can affect," stated Chief Carle.

Managing the stress associated with a complex novel incident has a direct relationship to the ability to identify key factors of the incident and actively evaluate associated information. The decision maker's ability to take in information about his surroundings is critical to the decision-making process. This cannot happen if the decision maker is over-aroused to the point of overload.

3. Open to the Environment

The relationship between the commander and the incident environment was a common theme in many successful examples given of decision making under complex and novel circumstances. Lt Leonard gave an example of stepping away from an incident in order to think better,[12] and overhearing a conversation where two people outside his organization were discussing their ideas for the problem he was working on. Lt Leonard believes that if he had not been listening and aware of his surroundings, it would have been very easy to have not heard or even ignored the conversation, therefore missing a great idea. Chief Downey illustrated how the incident environment includes not only external factors but also the condition of one's team. The commander must consider as many factors concerning the incident as possible, from monitoring incident progress, to

[12] See Chapter V, Section D, for a more detailed description of this incident.

understanding the people involved, to the political implications. In a complex environment, this is difficult as the number of unknowns may very likely outnumber the known.

4. Active Role in the Process

Another common theme of the commanders interviewed was their conscious decision to take an active role in the decision-making process despite their inexperience in the situation. Lt Leonard was only a sergeant at the time of the incident he discussed. At this incident, there was a lieutenant on scene who offered several possible courses of action for getting a man out of a window sill. Even though he was outranked, Lt Leonard repeatedly rejected the suggestions offered by his superior after evaluating each one, because the risk of injury was too great for the person in the window. Instead of letting a ranking officer proceed with a bad decision, Lt Leonard actively searched for a reasonable alternative that later proved to be successful.

A fire captain who had only held this rank for a short time prior to the beginning of the Southern California 2007 fires noted:

> We were listening to the radio, hearing guys I work with. We were listening to evacuations and the fact that there were probably people that were going to die. I had a month of planned vacation, I was off, I was gone as far as they knew. And yet I felt I had to go to work. There was a sense of duty.

Even though this captain was on leave from his department, he reported to work, found enough people to make a complete crew, and started fighting fire. This sense of duty was a driving force for many who found themselves in situations of command despite their inexperience.

5. Mental Simulation

Mental simulations are an integral part of Klein's RPD decision-making model, where decision makers draw on past experiences in order to determine whether a proposed tactic could be successful if applied. However, even without experience as a reference, there were eighteen examples of mental simulations. Officer Dormann recalled

scanning a room he had never been in before for possible hiding places of weapons. When the person of interest reached for a drawer, he already knew what he would do because he had mentally simulated it only moments before. Another police officer noted that he imagines possible shooting incidents and predecides tactics when he waits at red lights in his patrol vehicle. When he was asked to develop a plan for fighting a fire in his own neighborhood, one fire captain got to implement a plan that he had simulated in his mind years before. While these simulations are common practice in public safety disciplines, the fact that they are being applied in novel circumstances is significant. The key difference between this finding and Klein's RPD is that it appears these commanders are able to create a mental model and evaluate potential outcomes even without direct past experience to use as a comparison to evaluate success.

6. Collective Problem Solving

Collective problem solving was noted in most of the successful examples of decision making. Both the police and fire disciplines have a system of progressive higher ranking officers that respond to any incident. The dispatch of these ranking officers is meant to be resources for the incident commanders, with standard operating procedures commonly stating that the most experienced and most appropriate person on scene should be the incident commander, not the person with the highest rank (FEMA, 2010). Both police and fire gave examples of staff being consulted on decisions during these complex and novel incidents. In the example from the 2003 Cedar Fire, fire chiefs met informally by the road to discuss the fire behavior and offer ideas for possible tactics. For Officer Lehan-Nichols, she enlisted the help of other officers, including an officer that spoke Spanish, to help her understand what was going on and make the right decision. The aggregation of multiple perspectives and ideas was seen as a benefit to the decision-making process. Some incident commanders consulted their superiors, others consulted their staff, and some sought outside subject-matter experts.

7. Perspective

A common trait in novel situations is a narrowed perspective of the situation as a whole. Officer Dormann gave an example of a time when he was serving a warrant and

was locked inside the house by family members and had to call for backup. In this example, their focus had been on controlling the person of interest in the house, and they had not realized the risks of the other family members in the residence.

Chief Carle cited the example of a tanker fire. The initial staff on scene had been concerned with putting out the fire, which was not at risk of spreading. In the meantime, fuel was leaking into a watershed nearby. The firefighters had only concentrated on the fire and had failed to look at the larger implications of the incident, including environmental damage. In general, a higher likelihood of achieving incident objectives was noted when a wider, rather than narrower, perspective was utilized when observing the incident environment.

8. Information

Gathering information regarding the multiple factors impacting an incident is also important to the decision making. In almost every interview, the research subject mentioned a lack of information initially. Where the research subjects varied was what they did to improve their situational awareness. Both Chief Fennessy and Chief Gardner gave examples of incomplete or incorrect data, including inaccurate incident locations and wrong unit numbers. Both actively questioned the validity of the data given and pushed staff to reconfirm information that did not seem correct. Chief Fennessy discussed sending multiple spotters to the area, and even requesting unified command with another agency in order to ensure he was getting as much information about the incident as was possible. In describing a radio call regarding a situation where a fire crew was trapped by fire and needed assistance, Chief Gardner recalls:

> She gave the wrong engine number because she was a cover person. She was normally on another engine. So the delay of what was probably two minutes, but it seems like it was two hours, going to roll call, calling the fire station of the fire engine she screamed that was not assigned to the fire, trying to figure out if it was a hoax. Was somebody really sick? We couldn't figure it out. We brought everything else to a screaming halt. Seven or eight people were trying to get the picture, find out the facts, and determine what our next step was.

In both cases, the gathering of information was a key part of the process, often leading to a change in tactics as new information was learned.

9. Trust

Trust was noted as a factor twelve different times during the interview process. Trust included trust in themselves and their team, trust in the plan, trust that tactics training would be remembered when the time came. Trust is a valuable tool in overcoming the doubt that can lead to uncertainty and inaction. Trust cannot be taught or trained, but it is something that can be stressed in the development of a novice personnel. Both fire and police commanders mentioned the value of training in stressful situations in order to build this trust in advance. It was noted that experience did not have to be directly applicable to the incident in order to be valuable. Just knowing how you will react and trusting your instincts under stress was considered enough.

10. Comfort in the Unknown

An interesting finding in analyzing the interviews was that often, successful commanders found comfort in operating in unknown situations. Chief Fennessy notes:

> It depends on the individual. Some people thrive on the chaos. It is almost a calming thing, knowing that there are not necessarily any rules, whatever they decide to do.

When considering a tactic never tried before but suggested by colleagues in another discipline, Lt Leonard stated, “I was looking for something to do that would be right. I thought, well, why not?” Instead of unknowns inhibiting action, these decision makers viewed their decisions as opportunities to test, and were comfortable with the possibility of a negative outcome. To them, the unknown complex circumstances lessened the consequences of failure and allowed them more of an opportunity to experiment, because any action was better than none.

D. REDUCTION OF CODES TO RELEVANT CONCEPTS

Two concepts emerged from the coding process of the interviews when compared back to the original research question: What is the process for making decisions in complex novel situations?

1. Naturalistic Decision Making

Based on their own descriptions of their processes, the commanders interviewed did indeed seem to be using a form of naturalistic decision-making process. At no time during the interview process did the research subjects discuss evaluating multiple options simultaneously to determine the optimal solution. Instead, testing and probing through the implementation of possible satisfactory tactics singularly was preferred. In using naturalistic decision making to make decisions associated with an incident, there were also many similarities to the processes described by Klein's RPD, even though Klein states that experience is a critical component of the RPD concept. Figure 4 shows three of the most common themes found and their relationship to RPD.

When discussing possible tactics to remove a person from a dangerous window-ledge, Lt Leonard used a modified form of the RPD model to evaluate the possible solutions offered by people around him. He rapidly examined each tactic singularly by mentally simulating potential outcomes based on what he knew about the situation and the proposed tactics to identify potential outcomes. Those outcomes were then compared to the goal he was trying to accomplish, which was to get the person out of the window sill safely.

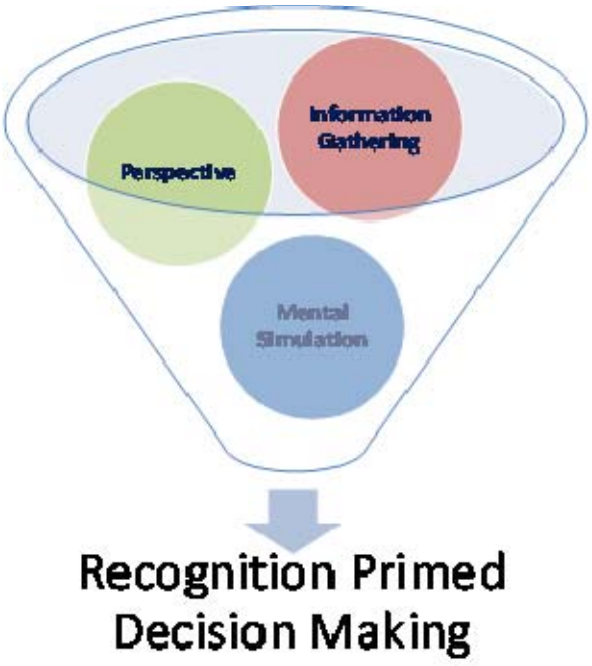

Figure 4. Distillation of Codes to RPD

Similarly, a fire captain was able to singularly evaluate tactics and make decisions using the experience of elders in the fire community, including his own father. Evaluating known geography of the area, and the experiences learned from conversations with people who had been involved in past fires in the area, he was able to develop a mental simulation of how the fire might behave and then test each possible solution through that filter as they were considered, until a satisfactory one was found. Based on examples in this study, it is possible that a modified version of Klein's decision-making process could address the need for experience in order to apply the concepts of RPD if an alternative way of recognizing patterns could be found.

2. Complexity Theory

The other realization during the research process was that many of the concepts identified during the coding process describe aspects of complexity theory (Figure 5).

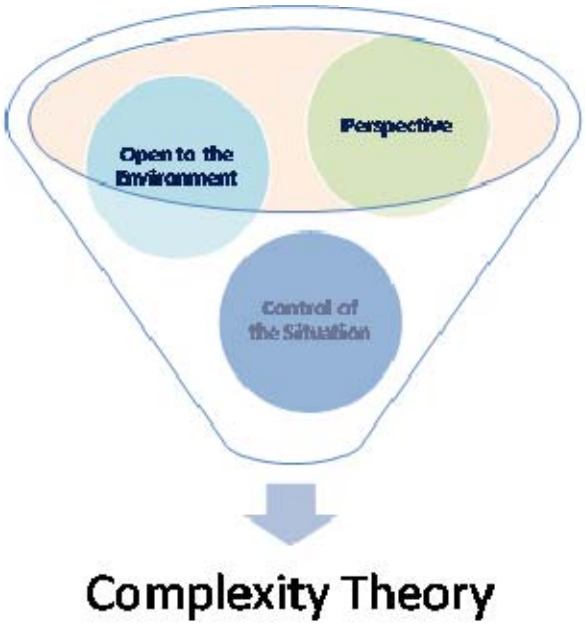

Figure 5. Distillation of Codes to Complexity Theory

Complexity theory looks at a system as a whole and is concerned with the agents involved, their ability to interact with each other, and the consequences of those interactions. Systems get progressively more complex as the number of agents increase or the number of interactions between the agents becomes more frequent. Figure 6 shows a cynefin framework, which is a descriptive model, dividing decision making into four domains: known, knowable, complex, and chaotic (Kurtz & Snowden, 2003). Each domain differs in knowledge about the relationship between cause and effect. In the complex quadrant of the cynefin framework, emerging patterns can be perceived but not predicted. This differs from chaos, where patterns can no longer even be perceived (Kurtz & Snowden, 2003).

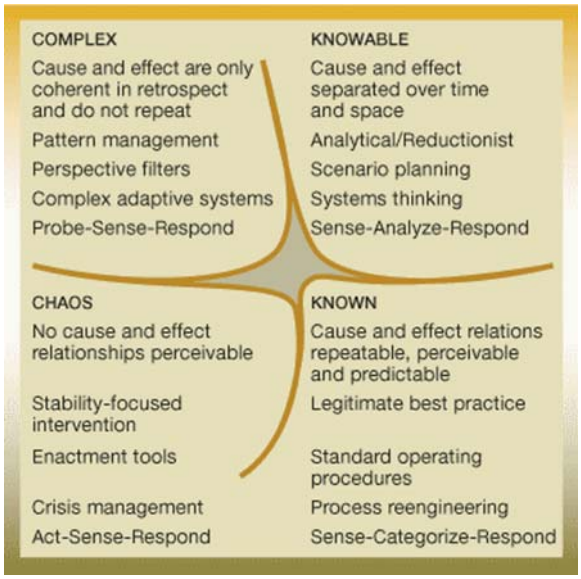

Figure 6. Cynefin Framework

The themes identified through the coding process also support the concepts of complexity theory. Table 2 lists the various codes discovered from the interview process that relate to concepts of complexity theory. This list represents 74% of the total number of codes generated.

E. CONCLUSION

While these two concepts, RPD and Complexity Theory, were derived at different times, from different schools of thought, relating the two concepts into a single model may offer new insight into the decision-making process in complex novel situations. Both theories focus on the value of information, especially the recognition of patterns. RPD's pattern recognition is based on personal experience, and the ability to draw parallels from past events for application to current events. Complexity theory takes the stance that due to the vast numbers of ways agents in a system can interact, no two situations are ever the same in a complex environment, and therefore, past experience may not matter as much as the ability to recognize and subsequently manipulate how agents in the system are interacting.

Codes	Count
Control of the Situation	41
Open to the Environment	21
Active Role in the Process	20
Collective Problem Solving	16
Perspective	15
Information	14
Trust	12
Comfort in Unknown Situations	9
Risk Assessment	9
Boundaries	8
Observation	7
Intuition	6
Action Oriented	5
Indirect Experience	5
Reduce to Complicated	3
Reassessment	2
Connected with the Environment	1
Instinct	1
Interactions	1
Relationships	1
Total Count of Occurrences	197 out of 266

Table 2. Interview Codes Associated with Complexity Theory

To discover how decisions are made in complex and novel environments, it is important to understand how and if these two concepts intersect, as shown in Figure 7.

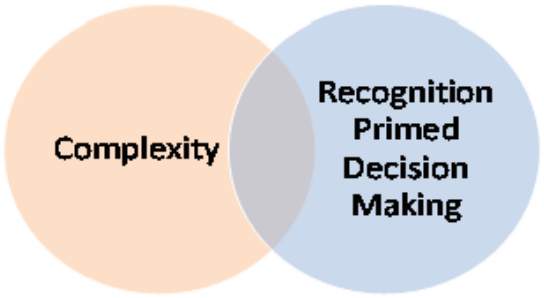

Figure 7. Combining RPD and Complexity Theory

In order to understand the relationship between the two concepts, both topics were selected for further research and consideration in development of a descriptive model of decision making in complex novel environments. The next chapter will outline the results of this additional study of existing knowledge on the two topics, and explore how the two could be combined into a process model.

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V. THE MASHUP: RPD + COMPLEXITY = EX^{2}DM

A. RECOGNITION-PRIMED DECISION MAKING (RPD)

Gary Klein's RPD work focuses on decision making in stressful and time-constrained environments. A significant finding from Klein was the realization that decision makers working in these conditions do not compare alternatives when making a decision, a process normally associated with rational analytical decision making. Figure 8 represents the rational analytical decision-making process where many options are developed and then evaluated simultaneously, with the best option selected.

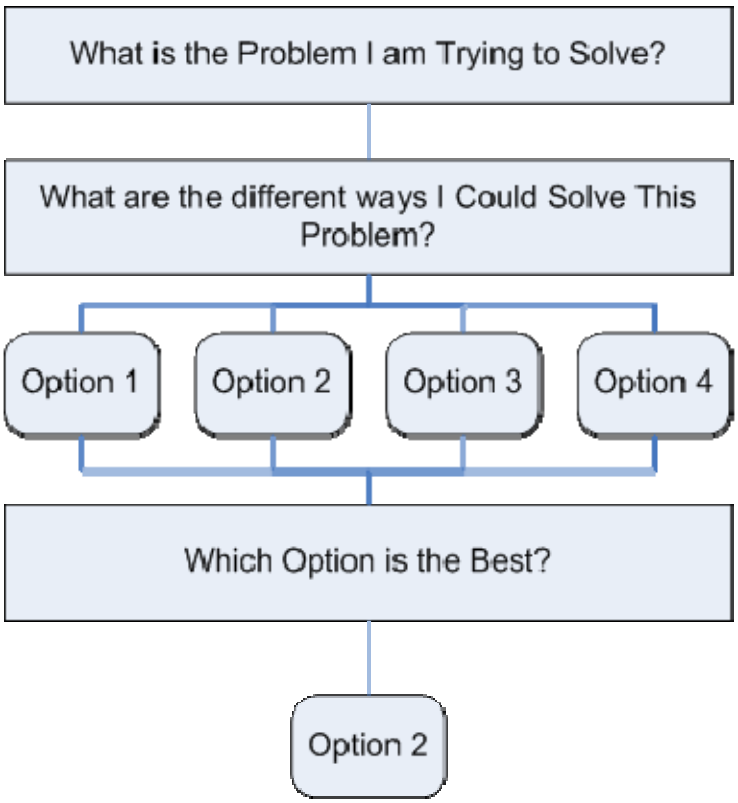

Figure 8. Rational Analytical Decision Making Process

With RPD, only one possible solution is identified for a given problem. The potential solution is evaluated using mental simulations based on past experience to determine if it will work. If it will not work, then that solution is discarded and the decision maker tries to identify another solution to evaluate. This process repeats until a

solution is found that will work. Figure 9 depicts the Klein's RPD process model detailing the steps of decision making under these conditions.

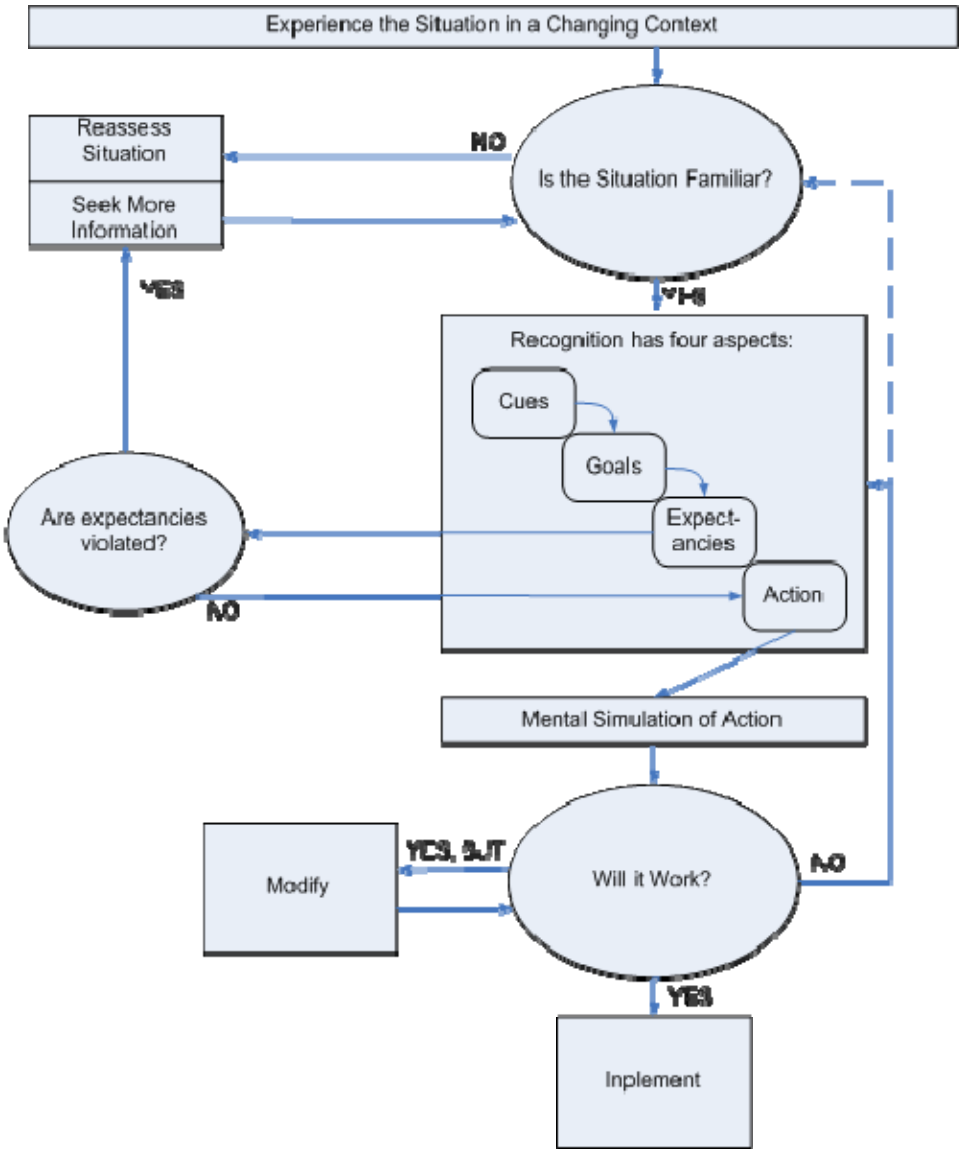

Figure 9. Recognition-Primed Decision (RPD) Model (After Klein, Orasanu, Calderwood, & Zsambok, 1995, p. 108)

The critical component of RPD is sensemaking. In this model, successful decision makers, operating under stress and limited time, "recognize important features of a problem and directly retrieve appropriate actions or solution techniques" (Klein,

Orasanu, Calderwood, & Zsambok, 1995, p. 63). The term recognition is used synonymously with pattern matching and is based on a personal mental library of past recollections of the decision maker. "New problems may be solved by recognizing their similarity to older, better understood problems and by appropriately transforming the old solution to take into account differences" (Klein, Orasanu, Calderwood, & Zsambok, 1995, p. 63).

An example would be a fire commander using past personal experience fighting wildland fires to predict how fast a current fire will spread. According to Klein, experience can aid in identifying causal factors that help the decision maker determine, based on past history, what is happening and, what will happen (Klein, Orasanu, Calderwood, & Zsambok, 1995). It is from these expectancies that goals can be determined. In the wildland fire example, the goal would then be to stop the fire before it spreads to the structures 100 yards away. Actions are evaluated through a serial approach to determine if they meet the stated goals (e.g., should a hand crew be used to cut a line?). Each potential action is mentally simulated to see if the action performed in the context of the current environment will meet the goals identified (will they have time to cut a line before the fire spreads to that location?). If the decision maker believes, after simulation, that the action will meet the goal, then it is implemented (even if more effective actions may be possible). If the action will not meet the goal, then it is either modified or rejected. If rejected, another action (e.g., water drop from aerial assets in the area) is identified and evaluated through the same process until a satisfactory action is found.

B. COMPLEXITY THEORY

Complexity theory has existed for over 100 years (Kurtz & Snowden, 2003). Central to complexity theory is the concept that complex systems cannot be understood simply by breaking down the system to its subcomponents. Instead, a more open and inclusive view of a system is necessary to constantly scan for small acts, which have the potential to incite larger disruptions in the system (Ramo, 2009).

Complexity theory accepts the basic unpredictability in one's environment. Instead of noting what is similar or familiar, complexity theory emphasizes focusing on

what is different or out of place (Ramo, 2009). In this paradigm, success is measured in one's ability to keep the enemy (human or environmental, depending on the situation) from adapting. This is done by intervening to stabilize desirable patterns and destabilize undesirable ones.

At the core of complexity theory are agents, artifacts, and interactions. Agents are people or things in a system that interact with the system environment, including other agents. Agents form populations, or groups of agents (often called a swarm), following simple rules and acting in similar behavior patterns. Artifacts are things in the system that impact agents and how they interface with their environment. Interactions can occur between agents or between populations. Table 3 gives examples of possible agents, artifacts, and interactions for a wildland fire.

Agents	**Artifacts**	**Interactions**
The fire	Topography	Putting water on fire
Firefighters	Fuels	Cutting fire lines
Civilians in the area	Weather	Setting back fires
Command staff and elected officials	Resources (fire engines, dozers, aerial support)	Evacuations
Other public safety (law, health, emergency management)	Housing developments	Refusal to evacuate
The media	Policies and procedures	Civilian rescues

Table 3. Potential Components of a Wildland Fire System

A system is then one or more populations of agents, the strategies of those agents, relevant artifacts, and the environment where the agents exist (Axelrod & Cohen, 2000). A system is complex when there are strong interactions between multiple agents that increase the number of possible future interactions at a later time.

Complex systems are often found to self organize. Order and patterns develop in a system via the repetition of interactions through and between populations. How much agents are allowed to interact can have large-scale impacts on the system as a whole. The allowance of multiple interactions can lead to avalanches, where a small change is propagated via a cascading chain reaction to cause an impact on the system up to the destruction of that system. In the wildland fire example, allowing a fire to reach a

structure at the edge of a neighborhood can then lead to a whole neighborhood burning as the fire moves from house to house in an unpredictable pattern. Conversely, the restriction of interactions can lead to self-restoring patterns, where a large change is insulated to only a certain population and the system is able to recover. By not allowing the wildland fire to reach the first structure, a whole neighborhood can be saved.

In this construct, strategy is "the way an agent responds to its surroundings and pursues its goals" (Axelrod & Cohen, 2000, p. 4) through the manipulation of agent interactions with other agents and the system environment. Strategies can occur at the agent or population level. Variety is created in a system through exploration and exploitation. Exploration is the search for new strategies and applies more to novel circumstances. Exploitation parallels Klein's RPD model of using past experience modified to match a current context. System resilience is then achieved by finding a proper balance between exploitation and exploration when making decisions.

In the domain of the complex, there are so many factors inter-relating, the cause and effect of these interactions is difficult to discern before or during the event. In fact, the inability to predict behavior during an incident is a key indicator that one is operating within the realm of the complex. Each interaction can change the course of future interactions. Once a wildland fire reaches the first structure, evacuations may become a higher priority than cutting a fire break. What we think will work now may not be viable a short time in the future. For this reason, decision makers must be flexible and not limited by the current plan. They must be constantly watching for signals of potential change, willing to update their understanding or even empathize with their environment (Ramo, 2009). As such, field commanders operating in this situation will need to be aware of how they receive and analyze data as part of their sensemaking to ensure they are not missing more subtle cues. Just a slight change in the wind can impact a wildland fire.

They should also be asking the following questions (Axelrod & Cohen, 2000):

1. What is the right balance between variety and uniformity?
2. What should interact with what and when?
3. Which agents or strategies should be copied and which should be destroyed?

Constantly evaluating the situations in terms of these questions allows the decision maker to think about manipulation of the system, even if they do not understand all of the components.

> Not having to understand the situation can be an important advantage. Indeed, most of the accomplishments of biological evolution, and much human social change, have occurred without the benefit of such explicit knowledge, let alone theoretical understanding. (Axelrod & Cohen, 2000, p. 88)

In the complex, what, how and when are far more important than why, because why can only be determined in hindsight. Accepting this basic premise of complexity frees the decision maker to focus only on the components of the system they are actually able to control: what are the agents in the system, how can they impact each other, and when should they interact in order to achieve a stabilizing effect for the incident as a whole? The initial over arching goal when attempting to manage a complex incident is first and foremost to shift the incident out of the complex realm and back to either the known or knowable, as per the cynefin framework. Operationally, this means stabilizing the incident to the point that standard operating procedures now apply consistently. This is done by manipulating the agents and interactions in the system, trying different strategies to shift the system back towards order. Strategies that result in increased order are exploited. In a wildland fire, if water drops are working, then do more water drops. Strategies that lead to chaos are terminated, and the decision maker then uses exploration to try something new (stop doing water drops and consider if a backfire would help accomplish your goal of protecting structures) and see how the interactions impact the system as a whole.

There is also a benefit to gaining multiple perspectives, including those who have less experience, because the "methods, tools, techniques of the known and knowable domains do not work [in the complex]. Narrative techniques are especially powerful in this space" (Kurtz & Snowden, 2003, p. 470). Chief Downey recalls a rescuer from his team coming to him and making a case for why they should continue a search. "It was clearly communicated and quite honestly, I wasn't thinking about it, but I had shortened their rotation times amongst teams just because I knew the guys were getting tired and I think that translated to the guys that I was looking at rotating those guys out." Through communications between team members, the junior member of the team was able to articulate a concern of the whole team that their leader had not realized. For this reason, teaming experienced practitioners with novices can prove valuable, since a novice may be able to see patterns and offer a new way of attacking the problem without the burden of following how it has always been done. Additionally, the very act of talking through the problem between a novice and an expert can identify strengths and weaknesses of a plan that a single perspective would not provide.

In a complex system, individual parts combine in a way that does not equal the sum of these parts. For that reason, the incident commander must evaluate success and the impact of decisions in the context of the individual population or area it is exercised, as well as from the perspective of overall system stabilization. Both perspectives have meaning in a complex system and neither should be ignored. A decision impacting one area has the potential to cause a chain reaction of events that can lead to overall incident destabilization. Constantly scanning the environment for subtle cues can minimize the risk of this occurring. Still the decision maker must remain vigilant.

C. EXPLORATION AND EXPLOITATION DECISION MAKING (EX^2DM)

Many of the concepts of Klein's RPD model have a foundation in complexity theory, including leverage and choke points, looking for differences, and the notion that an evaluation of a situation can actually alter the situation itself. However, Klein's RPD addresses only one type of strategy: exploitation. Figure 10 shows the result of modifying

Klein's RPD process model to incorporate the both exploitation and exploration: the known and the novel, into a new process model, Exploitation and Exploration Decision Making (Ex^2DM).

Ex^2DM is an expansion of the original concept of RPD presented by Klein. Ex^2DM accepts the premises of RPD, but presents the RPD model as one of two possible paths. The pivotal question in RPD, "Is the situation familiar?" excludes novel situations because it is reliant on the decision maker having experienced similar incidents in the past. In Ex^2DM, this question is used to differentiate the types of strategies the incident commander may want to consider: exploitation or exploration. For those situations where the decision maker has past experiences that could be applied to this new situation, the exploitation path is recommended, replicating Klein's RPD. However, if the situation is not familiar, then the path of exploration, the search for new strategies, should be considered.

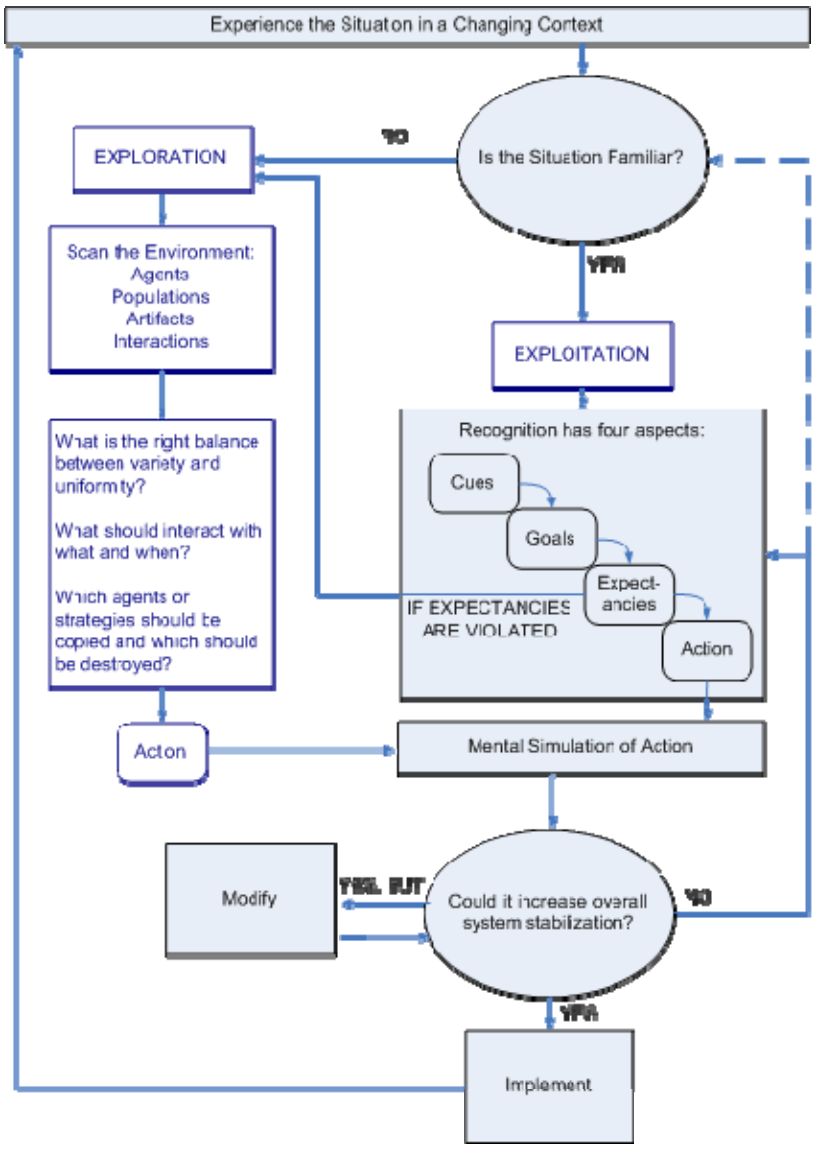

Figure 10. Exploration and Exploitation Decision Making (Ex^2DM)

Under the exploration path, the incident commander is encouraged to scan the environment from a wider perspective in order to define the system. Understanding the system includes knowing the agents who are involved, if they are assembled into populations, whether there are aspects of the system that will impact potential interactions, and what interactions are already occurring. Table 4 provides an example of the types of agents, artifacts, and interactions the incident commander might be scanning for in a law enforcement incident.

Agents	Artifacts	Interactions
Suspect	Buildings	Police interviews with suspect
Known associates	Neighborhood	Police and known associates
Civilians in the area	Known Information about the situation, people involved	Civilian interactions with the suspect
Police	Resources of the suspect	Civilian interactions with known associates
Other public safety (example: fire if there is an injury)	Resources of the police (additional police, aerial support, special teams)	Civilian interactions with the media
The media	Policies and procedure	Media at the scene

Table 4. Potential Components of a Suspect Interview

Armed with this perspective, the decision maker can then use three questions in order to determine where best to concentrate efforts:

1. What is the right balance between variety and uniformity?
2. What should interact with what and when?
3. Which agents or strategies should be copied and which should be destroyed?

These questions lead the strategist to consider the various components already at play and determine which should be encouraged and which should be prevented. The answers to these question lead to potential actions to influence the system. In a law enforcement example, it may be the decision to take a person of interest wanted for questioning to an area away from the public and known associates of the person, in order to ensure greater control of the situation by creating barriers to limit interactions.

In a complex situation, where outcomes are difficult to predict, one cannot know in advance exactly how a particular strategy will affect all aspects of the system. Whether using exploitation or exploration, the strategist uses mental simulations to identify potential issues with implementing the plan. The criteria for evaluating possible actions changes slightly from the RPD model, where the question was “Will it work?” In

a complex environment, one cannot know definitively if any strategy will work; there are simply too many potential interactions. For Ex^2DM the criteria is, "Could it increase overall system stabilization?" For law enforcement, the simple act of wanting to question a person of interest could result in an arrest or turn into a mob scene. The decision maker must determine if the potential gain is greater than the possible risks.

Once a strategy is selected and implemented, the process does not end. Instead, it loops back to experiencing the situation. In complexity, a single strategy is unlikely to solve all problems. It might, there is always that potential, but if that happened, the system probably did not have as many possible outcomes as originally considered. In the complex quadrant, where the potential for several combinations of actions will decide future outcomes, it is more likely that successful stabilization will require many decisions with multiple assessments of progress throughout the incident.

D. A CASE STUDY: THE FIRE HOSE AS A NON-LETHAL WEAPON

When responding to a call for service at a second-story apartment building, Lt Leonard found a male who was reportedly high on drugs (INFORMATION[13]) and was going crazy in the house. Upon arrival, Lt Leonard found the male standing in broken glass in the sill of an upstairs bay window. Lt Leonard was a sergeant at the time, and his lieutenant was at the scene. The lieutenant was pressuring him to use his baton to pull the person out of the sill (EXPLOITATION, OPTION DEEMED NOT VIABLE). Other options presented by the lieutenant were to use a Tazer on the individual (EXPLOITATION, OPTION DEEMED NOT VIABLE). As each option was presented, Lt Leonard reported that he thought through how the tactic would be applied (MENTAL SIMULATION) and he was concerned that there was a strong likelihood that the man would fall backwards out of the second story window, which would certainly injure him and could kill him (GOAL – GET THE MAN OUT OF THE WINDOW WITHOUT INJURING HIM). When a possible tactic was discounted, another option was considered, showing a singular evaluation when searching for an appropriate action (RPD). After

[13] In this section, concepts discussed previously associated with the Ex^2DM model are noted in all caps and parenthesis. For example: (MENTAL SIMULATION).

discounting a few different options, and not seeing an obvious solution, Lt Leonard excused himself from the situation, reportedly to go outside to think for a moment away from the pressure of the scene (CONTROL OF AROUSAL). He wanted to find a place where he could think for a minute, and have a conversation with God.

"Part of that is removing yourself a little bit from the situation and giving yourself time to actually have things kind of come to you." While walking down the stairs, Lt Leonard passed two EMTs who had been staged by the fire department. The two EMTs were having a private conversation, and Lt Leonard overheard (OPEN TO THE ENVIRONMENT) the following: "too bad they can't just shoot him with the fire hose." Lt Leonard did a mental simulation and determined that the solution might work (EXPLORATION, OPTION DEEMED VIABLE) and went to talk to the fire captain also staged at the scene (COLLECTIVE PROBLEM SOLVING). The two worked out a plan where the man was distracted by the police officers until a signal was given over the radio. At that time, the firefighters pressurized their hose, spraying the man with water from the outside, pushing him inside the apartment. The plan included several contingencies, since Lt Leonard had never used a fire hose as a non-lethal use of force before, (COMFORT IN THE UNKNOWN) and therefore had difficulty predicting the outcome (COMPLEXITY). The plan worked, and they were able to use the force of the water to push the man inside the apartment and get handcuffs on the man before he even realized what was happening. No one was hurt, and the apartment suffered only minimal damage, mostly the clearing of the popcorn from the ceilings.

E. CONCLUSION

A decision-making process that incorporates complexity theory prepares the commander to be cognizant of a situation as a complex interconnected system, with the hope that desirable patterns will appear and can be encouraged (Kurtz & Snowden, 2003). For incident commanders, this involves studying the environment from a wider, more encompassing perspective: watching for new changes, and determining if these changes benefit overall system stabilization. This is fundamentally different than taking a large complex incident, dividing it geographically or by responding discipline, breaking

the problem down to pieces, and managing each piece individually. This is not easy for most. People want to minimize and compartmentalize a problem to try and make it easier to comprehend. However, simplifying a problem runs the risk of missing relationships between different aspects of the system that may lead to unexpected outcomes. Monitoring an incident holistically, and making decisions based on exploration and exploitation of multiple tactics can mitigate unexpected chain reactions that may start small but can quickly destabilize an incident.

Ex^2DM is supported by the fact that many components of complexity theory have already been suggested by experts in the decision-making field. Klein developed the concept of leverage points, defined as a small difference that makes a large impact to create a new course of action. He asserts that the key is to notice something that is causing difficulty before there are signs of trouble, and mitigate the impact before things get out of control (Klein, 1998). This is a key component of complexity theory illustrated by Bak's avalanche experiment (Axelrod & Cohen, 2000). Gladwell also provides an example of military commanders who become so focused on the mechanics and the process of information gathering and assessing, that they never look at the problem holistically (Gladwell, 2005). Addressing the situation as a single complex system, not just a sum of its parts, is a core component of both complexity theory and naturalistic decision-making models such as RPD.

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VI. EVALUATION OF THE MODEL

A. EVALUATION OF EX^{2}DM AS A GROUNDED THEORY

According to Glauser and Strauss, pioneers in Grounded Theory, any theory, hypothesis, or new model developed based on the description of actual practice can be evaluated to determine if the new concept is valid and therefore applicable on a wider scale (Glauser & Strauss, 1967). Table 5 presents the results of the evaluation of Ex^{2}DM against the five criteria for new concepts developed using Grounded Theory.

Grounded Theory Evaluation Criteria	**Results for Ex^{2}DM**
Enable prediction and explanation of behavior	Ex^{2}DM was developed to explain the behavior of actual decision makers based on interviews performed as part of this research.
Be useful in theoretical advancement in the subject	Ex^{2}DM builds upon existing knowledge in the area of decision making under stress and time constraints, by offering a model that no longer excludes situations where the decision maker does not have past experience.
Be useful in practical solutions	Ex^{2}DM, while developed based on complex incident command scenarios for public safety, may be applicable to any complex situation where a decision must be made.
Provide perspective on behavior	In complex novel situations there exists a gap in the research pertaining to how strategies are developed in absence of past personal knowledge of a similar situation. Ex^{2}DM addresses how actual incident commanders work through the problem.
Guide and provide style for more research	More research could be performed to develop and refine the model based on additional case studies. Further research could also pursue if application of this model would improve future incident management in complex novel environments.

Table 5. Evaluation of Ex^{2}DM as a Grounded Theory

B. EVALUATION OF EX^{2}DM AGAINST THE RESEARCH QUESTION

In addition to determining whether Ex^{2}DM is a substantive model, it is also important to evaluate it against the original research question:

What is the process for making decisions in complex novel situations?

Ex^{2}DM details a process used by fire and law professionals. When the 2007 wildfires in San Diego County became too complex to comprehend based on the information they were receiving from citizens and firefighters in the field, Chief Fennessy sent spotters to the scene to identify and classify agents, artifacts, and interactions of the fire complex (see Table 2 for examples). He then used that increased situational awareness to evaluate the impact of current actions and determine if changes were necessary. Decisions were made to confront certain portions of the fire while allowing other portions to continue unchecked. He was attempting to control when (not if) fire would hit neighborhoods that needed to be evacuated. When strategies worked, the chief exploited them. When they were not successful, he explored new ideas.

In a law example, a better understanding of the incident as a complex system could have aided a police officer confronted with a mob after trying to make an arrest on the beach during a crowded holiday weekend. Classification of agents (bystanders, other police in the area), artifacts (the hot summer weather, alcohol consumed, previous police interaction with the beach goers) and interactions (bystanders forming a mob and attacking the police officers) might have provided a better understanding of the environment, which would have highlighted the need to explore different tactics for controlling the scene.

Ex^{2}DM is a theoretical descriptive model. As such, it offers insight into how some have been able to overcome the harsh conditions of managing a complex incident. Any public safety professional can expect to encounter a complex incident during the course of their careers. This model provides a framework for future incident commanders to work through that may help them to overcome the fear and uncertainty

common in these types of incidents. Encouraging a wider perspective and looking for ways to explore interactions enables the decision maker to proactively navigate the complexity and stabilize the incident.

C. PRACTICAL APPLICATION OF EX^{2}DM IN PUBLIC SAFETY

1. Training

The integration of Ex^{2}DM into the common practices of incident commanders would require command staff to be trained on the general concepts of naturalistic decision making and recognizing complexity, as well as Ex^{2}DM model specifically. This could be accomplished through in-service training sessions or formal classes.

Commanders would be taught the characteristics of complex systems and how to define the system boundaries, agents, artifacts, and interactions. Incident mitigation would be framed in terms of system stabilization through the exploitation of previously known strategies and the freedom to explore new tactics through the decision framework. Decision makers would be encouraged to constantly scan the environment for changes and look for stabilizing and destabilizing patterns. Once patterns are identified, actions could then be adjusted to manipulate interactions, moving the system toward more familiar situations where standardized procedures are more effective. The goal of this training would be to make incident commanders familiar with the concepts—in a sense, giving them a tool to work through complex novel situations.

2. Resource Allocation

Throughout the interviews, collective decision making was noted. Multiple perspectives, creative ideas, and innovative approaches are the key to positively impacting a complex system (Snowden & Boone, 2007). Ex^{2}DM provides a decision model, which is applicable whether the strategist is alone or working in a group. However, Ex^{2}DM benefits from as much inclusion as possible. Multiple people, and more importantly, people with diverse past experiences, improve the collective sensemaking by offering more potential strategies to exploit and a wider variety of creative ideas to explore.

> Relying on expert opinions based on historically stable patterns of meaning will insufficiently prepare us to recognize and act upon unexpected patterns. (Kurtz & Snowden, 2003, p. 469)

Assigning resources with varied backgrounds and levels of experience to roles in the command post can enable this cross-pollination of ideas. An incident command post for a large-scale incident is often a very busy place, and the intention is not to add more people to the mix, just to widen perspective. There are often many roles in a typical incident management team. Purposefully including personnel with a mix of backgrounds and expertise would accomplish the goal of having diverse perspectives to help monitor the incident and contribute new ideas.

3. Culture Change

Finally, for an organization to embrace Ex^2DM some degree of culture change will be necessary. In a complex situation, the right answers are not obvious. Instead, tactics must be evaluated and then tested, with the potential outcomes witnessed rather than predicted. This sort of environment does not mesh well with classic command and control styles of leadership. Being comfortable with trying new ideas, accepting that not all strategies will be successful, and encouraging creativity requires a more open and inclusive form of management.

Incident commanders fall back to what they know and are comfortable with in stressful conditions. If an organization does not allow creativity and collaboration in its normal operations, its commanders will not be comfortable incorporating new ideas during complex incidents. An organizational culture that values new ideas and respects the collective knowledge of the more experienced members will enable decision makers to feel comfortable utilizing Ex^2DM when an incident is sufficiently complex to warrant it.

D. LIMITATIONS OF THIS RESEARCH AND SUGGESTIONS FOR FUTURE STUDY

The research conducted in this thesis does have its limitations. First and foremost is the small sample size of research subjects interviewed. With the opportunity to interview additional incident commanders, it is possible that other themes would have been more prevalent than the ones exposed in this study. Interviewing a greater number of decision makers across a diverse geographical area is beyond the scope of this thesis, but would be an excellent opportunity to expand the body of knowledge regarding the practical application of decision making under stress. As noted by both Klein and Weick, public safety professionals are excellent research subjects in this area due to their stressful working conditions and variety of situations they encounter (Klein, Orasanu, Calderwood, & Zsambok, 1995; Weick & Sutcliffe, 2001).

Because Ground Theory methodology was used to generate the Ex^2DM model, it might be beneficial if future work used deductive, rather than inductive, methods. Testing the Ex^2DM model deductively would be a way to confirm or refute the findings presented here. A possible experiment could be to train novice strategists in the concepts of Ex^2DM and then judge their performance in simulated incidents to determine if advanced knowledge of the model and its supporting concepts could improve the quality of decisions made when applied to a novel scenario. Also interesting would be an experiment to determine if using Ex^2DM would reduce any of the physical responses associated with stress and overload for incident commanders.

Finally, this thesis studied public safety professionals who respond to critical incidents. However, complexity exists outside of natural disasters, terrorist events, and other catastrophes. Ex^2DM may be applicable to any environment where a person is attempting to manipulate a complex system. Making this leap, however, would require further research outside the scope of this project.

E. CONCLUSION

The field of homeland security centers on the prevention, preparedness, response, and recovery from incidents occurring on our nation's soil, whether natural or man-made. Yet, it is difficult to prepare for, or prevent, incidents that have not yet been envisioned. In these cases, how we respond becomes critical. Incident commanders, who incorporate concepts of complexity theory into their orientation process through the use of Ex^2DM, have the tools they need to work through any complex problem, even if it is completely new and beyond the bounds of anything experienced in the past.

By viewing incidents as complex systems, decision makers become aware of emergent order, even if they are unable to control it. Complexity theory offers a new way of addressing problems, a perspective where even in a lack of order, patterns from interactions between agents can be perceived and new methods of thinking can emerge (Kurtz & Snowden, 2003). This wider perspective, and comfort in the knowledge that not everything is controllable, offers the decision maker an opportunity to be creative and discover new ways to change the course of an incident.

Decision making is an important part of incident response, but we cannot forget that our decisions must lead to action. Retired Battalion Chief Tom Gardner notes, "You can't talk it out. Eventually, you have to go out there and put the fire out." Whether it is a fire, a search and rescue mission after a major catastrophe, or an active shooter, these incident commanders are tasked with finding a way to sort through the complexity to get the incident stabilized with as little loss of life and property as possible. Eventually, decisions must be implemented.

Following the Ex^2DM model encourages incident commanders to consider options that in the past would not have been recognized as even a possibility, to try new ideas to see if they will work, knowing some may not. Uncertainty can paralyze a strategist. Ex^2DM helps to overcome this uncertainty by imparting the understanding that in the complex, prediction and absolutes do not apply. Every decision has a risk, but through an iterative process of trial and error, complexity can be reined in.

APPENDIX A: INTERVIEW CODES

OPEN CODE	AXIAL CODE
Ability to act under pressure just as important as training and experience	ACTION ORIENTED
Compelled to act	ACTION ORIENTED
Job assignment	ACTION ORIENTED
Looking for something to do	ACTION ORIENTED
Trained to get past uncertainty	ACTION ORIENTED
Action over pondering	ACTIVE ROLE IN PROCESS
Actively searching for solution	ACTIVE ROLE IN PROCESS
Any plan better than no plan	ACTIVE ROLE IN PROCESS
Challenge authority	ACTIVE ROLE IN PROCESS
Chose action over uncertainty	ACTIVE ROLE IN PROCESS
Didn't wait for information to come in, actively gathering	ACTIVE ROLE IN PROCESS
Don't let lack of resources hold you back	ACTIVE ROLE IN PROCESS
Fight for right decision	ACTIVE ROLE IN PROCESS
Getting people to offer input	ACTIVE ROLE IN PROCESS
Had to make a case	ACTIVOLE IN PROCESS
Hesitant to question authority	ACTIVE ROLE IN PROCESS
Looking for problems	ACTIVE ROLE IN PROCESS
Looking for problems and fixing before they become issues	ACTIVE ROLE IN PROCESS
Make your own luck	ACTIVE ROLE IN PROCESS
Managing personalities	ACTIVE ROLE IN PROCESS
Rally support	ACTIVE ROLE IN PROCESS
Sell decision to others	ACTIVE ROLE IN PROCESS
Sell the idea that this was not the usual incident	ACTIVE ROLE IN PROCESS
Start working plan B	ACTIVE ROLE IN PROCESS
Stepped into leadership role	ACTIVE ROLE IN PROCESS
Constantly re-evaluating	ASSESSMENT
Band aid fix, one step at a time	BOUNDARIES
Eliminate variables	BOUNDARIES
Experience teaches you boundaries and when to push them	BOUNDARIES
Small steps (1) scan (2) plan (3) resources	BOUNDARIES
Step by step	BOUNDARIES

OPEN CODE	AXIAL CODE
Stop emergent trends	BOUNDARIES
Stop it where it is right	BOUNDARIES
Use natural barriers to advantage	BOUNDARIES
Aware, overheard conversation	COLLECTIVE PROBLEM SOLVING
Bounce ideas off of SMEs	COLLECTIVE PROBLEM SOLVING
Collective experience	COLLECTIVE PROBLEM SOLVING
Comfortable collaborating because of informal sharing	COLLECTIVE PROBLEM SOLVING
Deference to seniority, seen as a learning experience	COLLECTIVE PROBLEM SOLVING
Group decision	COLLECTIVE PROBLEM SOLVING
Group decision, all or none	COLLECTIVE PROBLEM SOLVING
Group decision, overruled rank	COLLECTIVE PROBLEM SOLVING
Inclusion of other parties in the process	COLLECTIVE PROBLEM SOLVING
Informal network	COLLECTIVE PROBLEM SOLVING
Lack of seasoned mentors	COLLECTIVE PROBLEM SOLVING
Mentoring	COLLECTIVE PROBLEM SOLVING
Multi-person brainstorming	COLLECTIVE PROBLEM SOLVING
No way to act alone, had to rely on help due to model	COLLECTIVE PROBLEM SOLVING
Proximity to experience, informal mentors	COLLECTIVE PROBLEM SOLVING
Team decision	COLLECTIVE PROBLEM SOLVING
Choice is a good thing, not a bad thing	COMFORT IN UNKNOWN SITUATION
Comfort in chaos	COMFORT IN UNKNOWN SITUATION
Confidence in knowing that the Calvary is coming, focus on initial	COMFORT IN UNKNOWN SITUATION
Experience = confidence	COMFORT IN UNKNOWN SITUATION
Novelty is opportunity for creativity, no rules	COMFORT IN UNKNOWN SITUATION
Okay with going outside the boundaries of experience	COMFORT IN UNKNOWN SITUATION
Opportunity to change, change isn't bad	COMFORT IN UNKNOWN SITUATION
Personality types, how they act in non-emergencies	COMFORT IN UNKNOWN SITUATION
Worry about criticism	COMFORT IN UNKNOWN SITUATION
Connectedness	CONNECTED WITH ENVIRONMENT
Walked away from the pressure	CONTROL AROUSAL
Avoid panic	CONTROL AROUSAL
Control arousal	CONTROL AROUSAL
Dehumanize the problem	CONTROL AROUSAL

OPEN CODE	AXIAL CODE
Didn't control arousal	CONTROL AROUSAL
Disassociate yourself from the scene	CONTROL AROUSAL
External pressure to perform	CONTROL AROUSAL
Get past denial and start working the problem	CONTROL AROUSAL
Just kept going	CONTROL AROUSAL
Mitigate arousal	CONTROL AROUSAL
Self realization of overload	CONTROL AROUSAL
Stay disconnected, unemotional	CONTROL AROUSAL
Control arousal	CONTROL AROUSAL
Controlling arousal	CONTROL AROUSAL
Fight or flight	CONTROL AROUSAL
Inexperienced too aggressive	CONTROL AROUSAL
Isolated distractions and interactions	CONTROL AROUSAL
Over thinking personalizing	CONTROL AROUSAL
Things get missed when over aroused	CONTROL AROUSAL
Training—high confidence in performance of tactics	CONTROL AROUSAL
Uncomfortable in leadership role due to junior status	CONTROL AROUSAL
Controlled arousal by limiting information dispersal over radio	CONTROL AROUSAL
Controlled arousal, stepped away	CONTROL AROUSAL
God, source of comfort	CONTROL AROUSAL
Internal conversation	CONTROL AROUSAL
Over aroused, take off of the incident, mundane task to get them mindful	CONTROL AROUSAL
Controlling the environment	CONTROL OF THE SITUATION
Get away from what is holding you back	CONTROL OF THE SITUATION
Accept independent variables, serenity prayer	CONTROL OF THE SITUATION
Allow chain reaction	CONTROL OF THE SITUATION
Be more intimidating than adversary—control	CONTROL OF THE SITUATION
Cannot totally control, only manipulate	CONTROL OF THE SITUATION
Cascade	CONTROL OF THE SITUATION
Change control dynamic	CONTROL OF THE SITUATION
Control conditions	CONTROL OF THE SITUATION
Control surroundings	CONTROL OF THE SITUATION
Control the terms	CONTROL OF THE SITUATION

OPEN CODE	AXIAL CODE
Control time	CONTROL OF THE SITUATION
Control time and arousal	CONTROL OF THE SITUATION
Control variables	CONTROL OF THE SITUATION
Controlling individuals but not the swarm	CONTROL OF THE SITUATION
Couldn't control speed	CONTROL OF THE SITUATION
Decide to do nothing until help comes	CONTROL OF THE SITUATION
Did not mitigate bad circumstances	CONTROL OF THE SITUATION
Don't let the adversary be more comfortable than you	CONTROL OF THE SITUATION
Establish advance trigger points	CONTROL OF THE SITUATION
Fire was controlling the timetable, lost control of time	CONTROL OF THE SITUATION
Gather resources, even from nonconventional sources	CONTROL OF THE SITUATION
Loss of control	CONTROL OF THE SITUATION
Loss of control	CONTROL OF THE SITUATION
Mitigate what you can control	CONTROL OF THE SITUATION
More deliberate later in my career	CONTROL OF THE SITUATION
Move situation to one where you do have a proper tool	CONTROL OF THE SITUATION
Opportunity presented itself	CONTROL OF THE SITUATION
Ordinary circumstance goes awry	CONTROL OF THE SITUATION
Push to more controllable range	CONTROL OF THE SITUATION
Reacted to the situation	CONTROL OF THE SITUATION
Slow down time	CONTROL OF THE SITUATION
Someone else is controlling the situation	CONTROL OF THE SITUATION
Take advantage of an opportunity	CONTROL OF THE SITUATION
Take back control	CONTROL OF THE SITUATION
Trying to control the situation	CONTROL OF THE SITUATION
Unexpected circumstances, lost coping mechanism	CONTROL OF THE SITUATION
What you can control, what you can't	CONTROL OF THE SITUATION
Think long term	CONTROL OF THE SITUATION
Slow time = not get hurt	CONTROL OF THE SITUATION
Create the right conditions	CONTROL OF THE SITUATION
Denial	DISBELIEF
Disbelief	DISBELIEF
Non-specific training under stress	EXPERIENCE UNDER STRESS
Past experience in life and death	EXPERIENCE UNDER STRESS
Learned from the storytelling of elders	HISTORICAL KNOWLEDGE

OPEN CODE	AXIAL CODE
Check in with troops - gather intel from other sources, multiple perspectives	INFORMATION
Get good info	INFORMATION
Knowing if it is possible to get reliable information is a data point to consider	INFORMATION
Lack of communication	INFORMATION
Lack of information	INFORMATION
Language barrier—incomplete information	INFORMATION
Limited information	INFORMATION
Little information	INFORMATION
Manipulate resources to get information	INFORMATION
Missing information	INFORMATION
Multiple sources of intel to minimize uncertainty	INFORMATION
Questioning intelligence	INFORMATION
Wrong information	INFORMATION
Wrong information, start reconfirming immediately	INFORMATION
Commonalities between small and big incidents	INDIRECT EXPERIENCE
Indirect experience	INDIRECT EXPERIENCE
Variety of experience leads to experience	INDIRECT EXPERIENCE
Wide range of experience, life experience	INDIRECT EXPERIENCE
Experience under stress, not situational	INDIRECT EXPERIENCE
Instinctual	INSTINCT
Interactions	INTERACTIONS
Intuition	INTUITION
Intuition, things weren't stacking up right	INTUITION
No time to think	INTUITION
Think too much leads to uncertainty	INTUITION
Unconscious action	INTUITION
Very little thought, pondering	INTUITION
Break into sub-steps and solve each individually	ITEMIZATION
Ability to see wrong answer and discredit	MENTAL SIMULATION
Captain in command center, use experience to visualize	MENTAL SIMULATION
Counterargument considered before presented	MENTAL SIMULATION
Draw pictures	MENTAL SIMULATION

OPEN CODE	AXIAL CODE
Envision worst case and compared with available tools	MENTAL SIMULATION
Envisioned	MENTAL SIMULATION
Imagining a worst-case scenario	MENTAL SIMULATION
Imagining and planning ahead	MENTAL SIMULATION
Looking forward in time to answer what am I going to need	MENTAL SIMULATION
Mental pre-planning	MENTAL SIMULATION
Metaphor	MENTAL SIMULATION
Predicting forward, planning for worst case	MENTAL SIMULATION
Prediction	MENTAL SIMULATION
Preemption	MENTAL SIMULATION
Thinking about how to maintain order	MENTAL SIMULATION
Various possible combinations	MENTAL SIMULATION
Visualizing tactics	MENTAL SIMULATION
Visualizing worst case scenario	MENTAL SIMULATION
Checking but didn't stop action, watch as it unfolds	OBSERVATION
Monitoring	OBSERVATION
Observer not just actor	OBSERVATION
Trust by verify to eliminate uncertainty	OBSERVATION
Watching not doing	OBSERVATION
Look, request, do	OBSERVATION
Studying what is different, what is predictable	OBSERVATION
Be prepared for beyond expectations	OPEN TO THE ENVIRONMENT
Compassion	OPEN TO THE ENVIRONMENT
Environmental queries	OPEN TO THE ENVIRONMENT
Heard of but never seen	OPEN TO THE ENVIRONMENT
Knowledge of the environment just as important as direct experience	OPEN TO THE ENVIRONMENT
Listen	OPEN TO THE ENVIRONMENT
Listen	OPEN TO THE ENVIRONMENT
Not monitoring environment, less time to react, not controling time	OPEN TO THE ENVIRONMENT
Open to criticism, add to the intel	OPEN TO THE ENVIRONMENT
Open, scanning for opportunities	OPEN TO THE ENVIRONMENT
Proximity to scene	OPEN TO THE ENVIRONMENT
Recognize not a normal fire, don't have to know why or how	OPEN TO THE ENVIRONMENT

OPEN CODE	AXIAL CODE
Recognize variables you cannot change	OPEN TO THE ENVIRONMENT
Respect adversary	OPEN TO THE ENVIRONMENT
Scanning scene for clues to select tactics	OPEN TO THE ENVIRONMENT
Size people up	OPEN TO THE ENVIRONMENT
Subtle cues from environment and conditions	OPEN TO THE ENVIRONMENT
Technology can hinder environmental scanning	OPEN TO THE ENVIRONMENT
Understand the differences, not stuck on similarities	OPEN TO THE ENVIRONMENT
Watching for signs from the environment	OPEN TO THE ENVIRONMENT
What the team needed to stay mindful	OPEN TO THE ENVIRONMENT
General guidelines, overarching principle	OVERARCHING PRINCIPLE
Choices evaluated for long term impact	PERSPECTIVE
Didn't see the larger picture	PERSPECTIVE
Driven into bad decision by trying to be safe, small perspective of safe	PERSPECTIVE
Evaluating long term threat	PERSPECTIVE
Experienced long term solution, inexperienced focused on small problem	PERSPECTIVE
Historical perspective	PERSPECTIVE
Larger perspective	PERSPECTIVE
Larger perspective—avoid panic	PERSPECTIVE
Larger perspective more effective	PERSPECTIVE
Learn not to trust or over simplify	PERSPECTIVE
Narrowed perspective, focus only on the problem at hand	PERSPECTIVE
Not looking at bigger picture	PERSPECTIVE
Perspective of the larger incident	PERSPECTIVE
Perspective of the team	PERSPECTIVE
Study from afar, larger perspective	PERSPECTIVE
Clear priority, avert death	PRIORITIZATION
Conflicting priorities led to lack of perspectives	PRIORITIZATION
Over arching doctrine	PRIORITIZATION
Priorities set by doctrine	PRIORITIZATION
Priority—overarching principle	PRIORITIZATION
Resident safety, getting them prepared	PRIORITIZATION
The harm of doctrine, firefighters fight fire	PRIORITIZATION

OPEN CODE	AXIAL CODE
Adjust the plan when variables play out different than expected	REASSESSMENT
Checking	REASSESSMENT
Push back to complicated then apply tactics	REDUCE TO COMPLICATED
Reduce the emergency	REDUCE TO COMPLICATED
Try and de-escalate	REDUCE TO COMPLICATED
Relationships	RELATIONSHIPS
Acceptable losses	RISK ASSESSMENT
Calculated risk	RISK ASSESSMENT
Discounted severity	RISK ASSESSMENT
Failure = personal safety	RISK ASSESSMENT
Inexperienced have higher risk profile	RISK ASSESSMENT
Realistic assessment	RISK ASSESSMENT
Risk analysis	RISK ASSESSMENT
Risk assessment	RISK ASSESSMENT
Understood risk of failure	RISK ASSESSMENT
Every day is practice	RITUALIZATION
Get safe, scan environ, get a plan, stay mindful (no more than four things)	RITUALIZATION
Goal no longer have to think about it	RITUALIZATION
Pop quizes when not at an incident	RITUALIZATION
Ritualized behavior	RITUALIZATION
Ritualized doctrine, so they don't have to think about it, unconscious	RITUALIZATION
Negative evaluation, satisficing	SATICIFING
Satisficing	SATICIFING
Time does not equal experience	TIME
Do something	TRAINED TO ACT
Ask for what you need, only what you need (TRUST)	TRUST
Confidence of plan	TRUST
Do the right thing, build internal confidence	TRUST
Know your tools in the tool belt	TRUST
Not afraid	TRUST
Not enough motivation to get ahead of it, disbelief	TRUST
Second-guessing yourself	TRUST
Trust	TRUST

OPEN CODE	AXIAL CODE
Trust	TRUST
Trust	TRUST
Trust—the right people out there	TRUST
Trust in training to do the right thing	TRUST

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APPENDIX B: GENERAL THEMES FROM THE CODES

Codes	Count	Theme
CONTROL OF THE SITUATION	41	COMPLEXITY
CONTROL AROUSAL	26	RPD
OPEN TO THE ENVIRONMENT	21	COMPLEXITY
ACTIVE ROLE IN PROCESS	20	COMPLEXITY
MENTAL SIMULATION	18	RPD
COLLECTIVE PROBLEM SOLVING	16	COMPLEXITY
PERSPECTIVE	15	COMPLEXITY
INFORMATION	14	COMPLEXITY
TRUST	12	COMPLEXITY
COMFORT IN UNKNOWN SITUATION	9	COMPLEXITY
RISK ASSESSMENT	9	COMPLEXITY
BOUNDARIES	8	COMPLEXITY
OBERVATION	7	COMPLEXITY
PRIORITIZATION	7	
INTUITION	6	COMPLEXITY
RITUALIZATION	6	RPD
ACTION ORIENTED	5	COMPLEXITY
INDIRECT EXPERIENCE	5	COMPLEXITY
REDUCE TO COMPLICATED	3	COMPLEXITY
DISBELIEF	2	
EXPERIENCE UNDER STRESS	2	RPD
REASSESSMENT	2	
SATICIFING	2	RPD
ASSESSMENT	1	RPD
CONNECTED WITH ENVIRONMENT	1	COMPLEXITY
HISTORICAL KNOWLEDGE	1	RPD
INSTINCT	1	COMPLEXITY
INTERACTIONS	1	COMPLEXITY
ITEMIZATION	1	RPD
OVERARCHING PRINCIPLE	1	
RELATIONSHIPS	1	COMPLEXITY
TIME	1	RPD
TRAINED TO ACT	1	RPD

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