ORGANIZATIONAL RESILIENCY:

DEVELOPING ADAPTIVE CAPACITY FOR TIMES OF CRISIS

BY

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APPROVAL

The undersigned certify that this thesis meets master's-level standard of research, argumentation, and expression.

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DISCLAIMER

The conclusion and opinions expressed in this document are those of the author. They do not reflect the official position of the US Government, Department of Defense, the United States Air Force, or Air University.

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ABSTRACT

The world of complex adaptive systems is marked by disruptive changes. Crises occur when organizations encounter disruptive changes that exceed their adaptive capacity. Stress increases when these disruptive changes threaten the continued functionality or survival of an organization. Once stress approaches a tipping point, performance in routine and novel tasks decreases precipitously. In complex socio-technical organizations, the negative interactions between disruptive change, stress, and performance can produce a dynamic feedback loop that may result in organizational failure. Strong organizational resiliency provides off ramps that have the potential to minimize the negative dynamic effects of a crisis cycle. Organizational resiliency is an organization's adaptive capacity to anticipate, absorb, respond to, and capitalize on specific disruptive changes that threaten the functionality or survival of the organization. Strong resiliency is based on trust, a perceived organizational identity, and an open culture. Furthermore, preparedness, responsiveness, adaptability, and learning are four drivers of resiliency that enable graceful extensibility which is the ability to operate at diminish organizational capacity while maneuvering away from crisis-prone areas through resource transference. The implications of this study are that Air Force leaders of socio-technical organizations, should expect disruptive change, identify areas of brittleness, balance efficiency with adaptability, and employ different strategies to mitigate the negative effects disruptive changes have on novel or routine task performance.

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Introduction: The Nature of Crises and Stress

> *The task of leading during a sustained crisis—whether you are the CEO of a major corporation or a manager heading up an impromptu company initiative—is treacherous.*
>
> Heifetz, Grashow, and Linsky

If you were a downed aircrew in the South Pacific during the late stages of World War II, there was a high likelihood that a unique organization facilitated your rescue, the 2nd Emergency Rescue Squadron known as the "SNAFU Snatchers."[1] Between 1944 and 1945, the 2nd ERS rescued over 700 aircrew using the Consolidated PBY-5A Catalina flying boat.[2] Their use of "SNAFU Snatcher" as a nickname acknowledges the adaptive capacity required during complex operations to handle disruptive changes in wartime. Originating in World War II, the SNAFU acronym stands for Situation Normal: All Fouled Up.

This acronym recognizes that normal operating conditions in a complex world are often chaotic, disruptive, and difficult to predict. When SNAFUs occurred in the South Pacific air domain, pilots often found themselves in the water, and the 2nd ERS rescued these precious commodities. Formed through transferred Navy flying boats and naval aviation procedures, the Airmen in the 2nd ERS were an adaptive capacity developed by the Army Air Force during World War II to handle disruptive changes. Today, the operating environment is even more complex than in World War II, which increases the likelihood of crisis affecting an organization.

A recent Price Waterhouse Cooper (PWC) poll of 164 Chief

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[1] James Robert Teegarden, "Second Emergency Rescue - Mission Statement," Second Emergency Rescue Squadron, January 20, 2020, http://www.pbyrescue.com/History/mission.htm.

[2] Teegarden.

Executive Officers (CEO) across the spectrum of business showed that 65% of CEOs experienced at least one crisis in the previous three years and 30% expected to face one or more in the next three years.[3] Disruptive change is a reality these leaders must understand otherwise they are at risk of failing their mission responsibilities due to crisis. The stakes are high for these leaders because as Ronald Heifetz notes, the path to success is narrow and treacherous.[4] This is partly due to the role of complexity in today's operations.

Organizations today must increasingly rely on tightly coupled systems for day to day operations in which sub-system parts are not only connected but dependent on one another. These systems can be financial, social, or technical. However, regardless of their form, these tightly coupled systems present significant challenges to successful crisis detection and response. No one specialist or team can comprehensively understand the interdependence of subsystems, the second or third order effects of failures, or the speed in which these failures propagate. These dynamics are seen in numerous financial crises, supply chain crises, and human capital crises.[5] Both the existence of a complex systems-based environment and the seemingly inevitability of crisis, raises important questions about how organizations survive and thrive amidst such stark realities.

The questions this study explores are some of the most important questions for leaders of organizations. What is a crisis? What effect does the crisis-producing stress have on performance of routine and novel tasks? What is the best approach to handling the negative effects of stress? How do organizations balance brittleness and robustness within

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[3] Price Waterhouse Cooper, "Welcome to the Crisis Era. Are You Ready?," PwC, accessed May 7, 2019, https://www.pwc.com/gx/en/ceo-agenda/pulse/crisis.html.
[4] Ronald Heifetz, Alexander Grashow, and Marty Linsky, "Leadership in a (Permanent) Crisis," *Harvard Business Review*, July 1, 2009, https://hbr.org/2009/07/leadership-in-a-permanent-crisis.
[5] Price Waterhouse Cooper, "Welcome to the Crisis Era. Are You Ready?"

their operating envelope? What is organizational resiliency? How can merely focusing on stability create a culture that is unable to adapt in a complex environment? Answering these questions builds a foundation for answering the overall research question: how does organizational resiliency improve how Air Force squadrons detect and navigate crises?

The thesis of this study is that organizational resiliency is an organization's adaptive capacity to anticipate, absorb, respond to, and capitalize on specific disruptive changes that threaten the functionality or survival of the organization**.** This study develops a conceptual framework for understanding how disruptive changes, stress, and task performance interact in a dynamic and negatively reinforcing manner (See Figure 1).

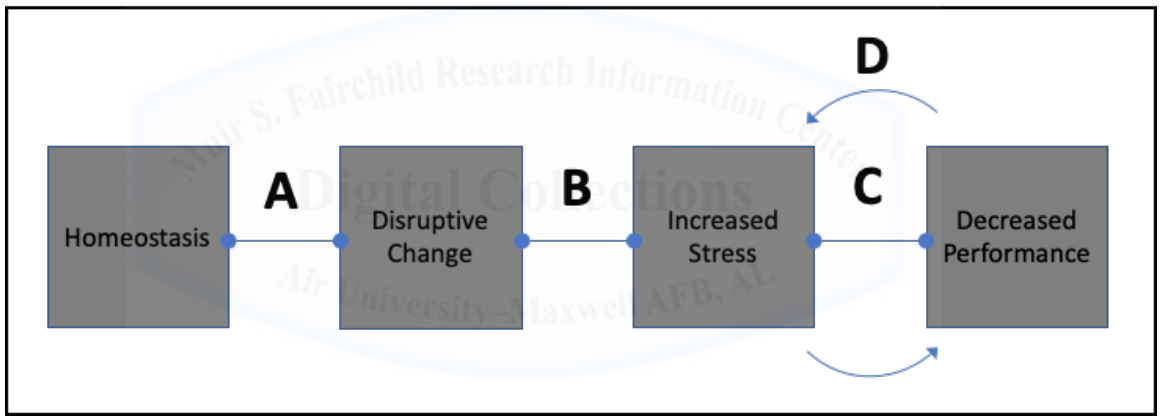

Figure 1: Crisis-Cycle Framework
Source: Author's Original Work

In this framework, strong organizational resiliency influences the pathway through crisis by opening up off ramps at different resiliency points (A,B,C,D) within the crisis cycle. The adaptive capacity inherent in strong organizational resiliency rests on three cultural traits and four drivers of resiliency. Finally, strong resiliency improves an organization's capacity to detect and navigate crises by identifying areas of brittleness within the organization's operating envelope and developing malleable and transferrable resources to navigate away from these crisis prone areas. In short, organizational resiliency helps leaders match the

complexity of their organizations with the complexity of the environment.[6]

This study has five basic sections divided into chapters. Chapter One explores the nature of crises and the way they produce stress in organizations. Chapter Two explores how stress influences performance during routine and non-routine tasks. Chapter Three develops the concept of organizational resiliency as an adaptive capacity to mitigate the negative effects of the crisis cycle. Chapter Four applies organizational resiliency to the case study involving the mistaken shootdown of Iran Air Flight 655 by the USS VINCENNES in 1988. Finally, Chapter Five concludes with recommendations for future research and a few guiding principles for strategists and Air Force commanders.

This chapter first lays out the necessity for studying crises given the reality of constrained resources and the presence of time pressure in decision-making. Next, this chapter establishes a working definition of a crisis as it relates to disruption, critical junctures, and threats to organizational functionality. Finally, this chapter describes how a crisis produces stress. In this way, this chapter understands a crisis as the result of disruptive changes in an organization's operating envelope. These disruptive changes produce stress which negatively affects task performance and exceeds the organization's coping ability. This dynamic process can ultimately threaten the organization's continued functionality and survival.

The Necessity for Studying Crises

The fact that crises are a reality of life suggests strategists ought to understand how they originate and what dynamics shape success and failure in crisis management. Crisis management requires integrating multiple disciplines including cognitive psychology, complexity thinking,

[6] Dawn R. Gilpin and Priscilla J. Murphy, *Crisis Management in a Complex World* (Oxford University Press, 2008), 27.

and organizational theory. Crises exist in a complex world involving flawed human heuristics, unconquerable forces of nature, and increasingly interdependent systems.[7] In terms of time, the presence of complex adaptive systems implies that crises unfold at a pace that stress organizational functionality and decision-making in a dynamic manner. This is due to the tight coupling of systems, as well as social and informational factors that allow errors to proliferate with unprecedented speed and effect. A strategist and commander should understand these dynamics for several reasons.

First, strategists and commanders generally operate in a resource constrained environment that is subject to constant change. This means they need to make real trade-offs to manage risk and uncertainty, which has implications for when, where, and how crises may occur in their organizational operating envelope. Second, in the globalized, tightly coupled, and information-fused world, time pressure influences the speed at which decisions must be made. Organizational resiliency embraces the reality of time pressure and seeks to develop capacities that offset the negative effects of time pressure thus increasing one's own comparative advantage against adversaries in a dynamic environment.

This paper, rooted in the inevitability of crisis, is aimed at Air Force squadron commanders who lead High Reliability Organizations (HRO). HROs conduct an array of highly interdependent and complex tasks in an uncertain environment.[8] Examples of HROs in organizational literature include aircraft carrier operations, emergency room operations, nuclear power plants, and air traffic control services to name a few. These organizations operate in an environment where systems are tightly coupled and avoiding catastrophic failure requires a degree of flexibility,

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[7] Arjen Boin, *The Politics of Crisis Management: Public Leadership under Pressure*, Second edition. (Cambridge, United Kingdom: Cambridge University Press, 2017).
[8] Marlys K Christianson et al., "Becoming a High Reliability Organization," *Critical Care* 15, no. 6 (2011): 314, https://doi.org/10.1186/cc10360.

procedures, and complexity.[9] Successfully navigating this environment requires a level of organizational resiliency whereby the organization can adapt to the negative interactions between stress and task performance as manifested in crisis. Changes in physical and social technologies mean that organizations that merely focus on stability over resiliency may be ill-equipped to avoid crises or fail to navigate them satisfactorily. Hence, organizational resiliency is a key characteristic that squadron commander should seek to improve within their organizations.

The Nature of Crisis

The word crisis originates in the Greek word 'krisis' meaning to sift or separate.[10] Crises, in this sense, tend to sift or separate an organization from their ability to function.[11] Conceptualizing crises takes varying definitional forms. One author views crisis as "a disruption that physically affects a system as a whole and threatens its basic assumptions, its subjective sense of self, and its existential core."[12] Another author notes, "crises are critical junctures in the lives of systems – times at which their ability to function can no longer be taken for granted."[13] Finally, one notes, "a crisis is a situation faced by an individual, group, or organization which they are unable to cope with by the use of normal routine procedures and in which stress is created by sudden change."[14] Regardless of which definition one finds most conceptually satisfying, together they highlight how perception of threat

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[9] Karlene H. Roberts, "Some Characteristics of One Type of High Reliability Organization," *Organization Science* 1, no. 2 (1990): 161.

[10] Gene Klann, *Crisis Leadership: Using Military Lessons, Organizational Experiences, and the Power of Influence to Lessen the Impact of Chaos on the People Your Lead* (Greensboro, UNITED STATES: Center for Creative Leadership, 2003), http://ebookcentral.proquest.com/lib/princeton/detail.action?docID=3007579.

[11] Klann.

[12] Thierry C. Pauchant and Ian Mitroff, *Transforming the Crisis-Prone Organization: Preventing Individual, Organizational, and Environmental Tragedies*, 1st edition (San Francisco: Jossey-Bass, 1992).

[13] Boin, *The Politics of Crisis Management*.

[14] Simon A. Booth, *Crisis Management Strategy: Competition and Change in Modern Enterprises*, 1 edition (Routledge, 2015).

to survival, stress, change, assumptions, systems, and routine are all dynamics influencing the emergence of crisis.

Four factors determine how crises emerge. First, the speed and urgency of disruptions determine how crises begin and end. Some emerge rapidly and end suddenly as in the Space Shuttle disasters NASA experienced in 1986 and 2003. Other crises are slower to emerge and slower to end. These take the form of natural disasters like famine and drought. Second, the organizational level of expertise in handling disruption impacts the duration and scope of the crisis. Third, the novelty of the disruption influences how quickly an organization can adapt to the crisis. Fourth, the organization's structural components of decision-making, hierarchy, culture, and communication flow shape the response capacity in the face of disruptions.[15] While one might strive to eliminate all possibility of crises emerging in the first place, several factors make disruptive changes inevitable.[16]

First, complex social interaction due to vast numbers of people working together in large organizations are bound to generate conditions leading to crises. These interactions can provide fertile ground for errors to propagate either in a technical sense or in a socio-cultural sense. Second, flawed human heuristics means that problem-solving and decision-making in daily operations are often inefficient or incorrect, creating a causal mechanism for crises.[17] Robert Jervis explored flawed heuristics through the dynamics of perception and misperception in the Cuban Missile Crisis which saw the world on the brink of thermonuclear war.[18] Third, humanity is largely unable to prevent and control the negative effect of natural and physical forces like hurricanes, floods, and

[15] Anthony Shorris, "Crisis Management" (Class One, Princeton University, Princeton, NJ, March 26, 2019).
[16] Jacob Ashmore, "Leading Through Crisis" (Woodrow Wilson School of Public and International Affairs, Princeton University, Princeton, NJ, May 14, 2019).
[17] Daniel Kahneman, *Thinking, Fast and Slow* (Farrar, Straus, and Giroux, 2011).
[18] Robert Jervis, *Perception and Misperception in International Politics*, New (Princeton, N.J: Princeton University Press, 2017).

earthquakes, which become sources of crises. For instance, there is a 70% likelihood that Japan will experience a catastrophic earthquake in the next 30 years similar to the one experienced in 2011 which claimed thousands of lives and triggered several nuclear accidents at nearby plants.[19] However, beyond these three historic reasons, two technological developments during the past century increase the likelihood of crises.

First, the world consists of many complex adaptive systems. Charles Perrow's theory of disasters in technological systems describes the complexity of modern systems make it difficult for anyone to fully comprehend the innerworkings of their parts.[20] Furthermore, the components of these systems are interdependent, which allows errors to proliferate through the systems with unprecedented speed and effect.[21] These complex and tightly coupled systems cause crises of varying type and scope.[22] For instance, the Space Shuttle Challenger and Columbia disasters are both examples of how complex and tightly coupled technological systems can fail catastrophically through one small error. Since the operational environment is increasingly marked by a system-of-systems, disastrous results in a subsystem can create vulnerability in the whole system.[23]

The global financial crisis in 2008 has its foundation in this phenomenon. Changes in the financial system in the decades leading up to the crisis allowed billions of dollars of rapid capitol flow in the span of a few seconds throughout vast and complex networks connecting private

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[19] Daniel Hurst, "'This Is Not a "What If" Story': Tokyo Braces for the Earthquake of a Century," *The Guardian*, June 12, 2019, sec. Cities, https://www.theguardian.com/cities/2019/jun/12/this-is-not-a-what-if-story-tokyo-braces-for-the-earthquake-of-a-century.

[20] Charles Perrow, *Normal Accidents Living with High-Risk Technologies*, Princeton Paperbacks (Princeton, N.J.: Princeton University Press, 1999), http://www.jstor.org/stable/10.2307/j.ctt7srgf.

[21] Boin, *The Politics of Crisis Management*.

[22] "Tightly Coupled Is a Term Originating in Computer Science Describing a System in Which Subparts, Often Hardware and Software, Are Not Just Connected Together but Dependent on One Another for Functionality." (n.d.).

[23] Ashmore, "Leading Through Crisis."

and public sectors.[24] This transaction process was something which few people fully comprehended. Moreover, second and third order effects of the solutions to address financial system vulnerabilities were not fully understood either. This cascading effect meant that attempts at fixing an individual crippled system's vulnerability resulted in a broader system failure. This recursive feedback loop of the financial system manifested itself in the 2008 subsequent Eurozone financial crises.[25]

The speed of disruptive change in complex systems creates a sense of pressure from time compression. The title of Bill Gates book on business and technology, *Business @ the speed of thought*, highlights this exact point. While many advantages emerge from operating at the 'speed of thought', several drawbacks exist. Complex and tightly coupled systems operating at the speed of thought increase their vulnerability as experienced in security, financial, and health crises. Moreover, these dynamics increase the consequences of any system failure because these consequences are immediate and widespread. This complex environment means crises can be caused by both nonroutine events and the cascading effects of routine events. Either way, these five factors – historic and technological – shape a world where crises are a reality. It is not a matter of *if*, but *when*, a crisis will hit your organization.[26]

Crisis Induced Stress

One of the previous definitions of crisis highlights the way a sudden change in situation produces stress.[27] In other words, one of the immediate byproducts of a crisis is the production of stress, whether it occurs at the individual, group, or organizational level. However, it is important to disaggregate the event from the stress. Characterizing a disruption or event as a stressful situation blurs a necessary distinction

[24] Boin, *The Politics of Crisis Management*.
[25] Ashmore, "Leading Through Crisis."
[26] Ashmore.
[27] Booth, *Crisis Management Strategy*.

required to understand stress.[28] In the case of crisis induced stress, it is important to disambiguate the stimulus from the response. The event, situation, or disruption is the stimulus. The perception of the situation is what generates the stress. This conceptualization highlights the complexity of stress as it relates to perception of internal and external factors.

Defining stress in a concrete manner is difficult. Thomas Steckler defines it as "any challenge to homeostasis that requires adaptive response."[29] Others defines stress as "conditions where an environmental demand exceeds the natural regulatory capacity of an organism, in particular situations that include unpredictability and uncontrollability."[30] When these defining attributes of stress are combined with the characteristics of crises, it follows that all crises produce some level of stress.

For instance, as previously noted, crises are marked by disruptions in systems that exceed their coping ability and threaten their continued functionality and survival. This dovetails extremely well with conceptualizing stress as challenging homeostasis, being unpredictable, and exceeding regulatory capacities of a system. Moreover, crises are likely to produce significant stress since the adaptive response required to overcome the challenge to homeostasis is likely beyond the capacity of the system or organization, at least in part. In other words, crisis conceptualized as a disruption can be thought of as the specific challenge to homeostasis offered in Steckler's definition. In short, stress is crisis' twin sibling. Wherever crisis occurs, stress will accompany it.

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[28] Alexander L. George, "The Impact of Crisis-Induced Stress on Decision-Making," *The Medical Implications of Nuclear War, National Academy Press, Washington*, 1986, 529–552.

[29] Thomas Steckler, N. H. Kalin, and J. M. H. M. Reul, *Handbook of Stress and the Brain Part 1: The Neurobiology of Stress* (Elsevier, 2005), 25.

[30] J. M. Koolhaas et al., "Stress Revisited: A Critical Evaluation of the Stress Concept," *Neuroscience & Biobehavioral Reviews* 35, no. 5 (April 1, 2011): 1290–1300, https://doi.org/10.1016/j.neubiorev.2011.02.003.

An important aspect of the relationship between stress and crisis is how stress and performance interact as disruptions in both novel and routine tasks occur in any given organization. This is the focus of Chapter Two.

Chapter 2

The Effects of Stress on Task Performance

> *As the system approaches its tipping point, the ability to sense its impending disaster is likely to decline.*
>
> Rudolph and Repenning

Chapter One characterized crises as situations, disruptions, or critical junctures that threaten an organization's continued functionality or existence. Furthermore, Chapter One also described how these situations, disruptions, or critical junctures produces stress as the entity perceives and engages in sense-making regarding the threatening disruptive change. This chapter describes how stress degrades task performance in both novel and routine tasks.

This chapter begins by discussing the general relationship between stress and performance and the role memory function plays in determining task type (novel or routine). Next, this chapter describes how stress decreases performance in any cognitive tasks requiring the explicit memory and executive function. These types of novel tasks are involved in crisis detection and response actions such as planning, decision-making, and problem solving.[1] Next, this chapter describes how large numbers of fast-acting interruptions during routine tasks can generate enough stress to overwhelm the coping mechanisms of an organization and create an tipping point leading to sudden nonlinear performance degradation.[2] Finally, this chapter concludes by developing a single crisis cycle framework which integrates the dynamic relationship between disruptive change, stress, and performance. Understanding how stress affects performance in both novel and routine tasks offers crucial

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[1] Sam J. Gilbert and Paul W. Burgess, "Executive Function," *Current Biology* 18, no. 3 (2008), https://www.cell.com/current-biology/pdf/S0960-9822(07)02367-6.pdf.

[2] Jenny Rudolph and Nelson Repenning, "Disaster Dynamics: Understanding the Role of Quantity in Organizational Collapse," *Administrative Science Quarterly - ADMIN SCI QUART* 47 (March 1, 2002): 1–30, https://doi.org/10.2307/3094889.

insights into how organizational resiliency may provide off ramps in the crisis cycle by improving crisis detection and response.

Stress, Performance, Memory, and Task Type

Traditionally, the relationship between stress and performance is depicted by an inverted-U-shaped function known as the Yerkes-Dodson curve (see Figure 2).[3] The inverted U-shaped function illustrates how performance initially increases under low levels of stress or arousal. However, after reaching an optimal stress level, performance continuously and then exponentially decreases with additional stress. While this function is a useful conceptual framework, the interaction between stress and performance is far more complex. The interacting features of stress, cognition, and memory function illustrates this complexity.

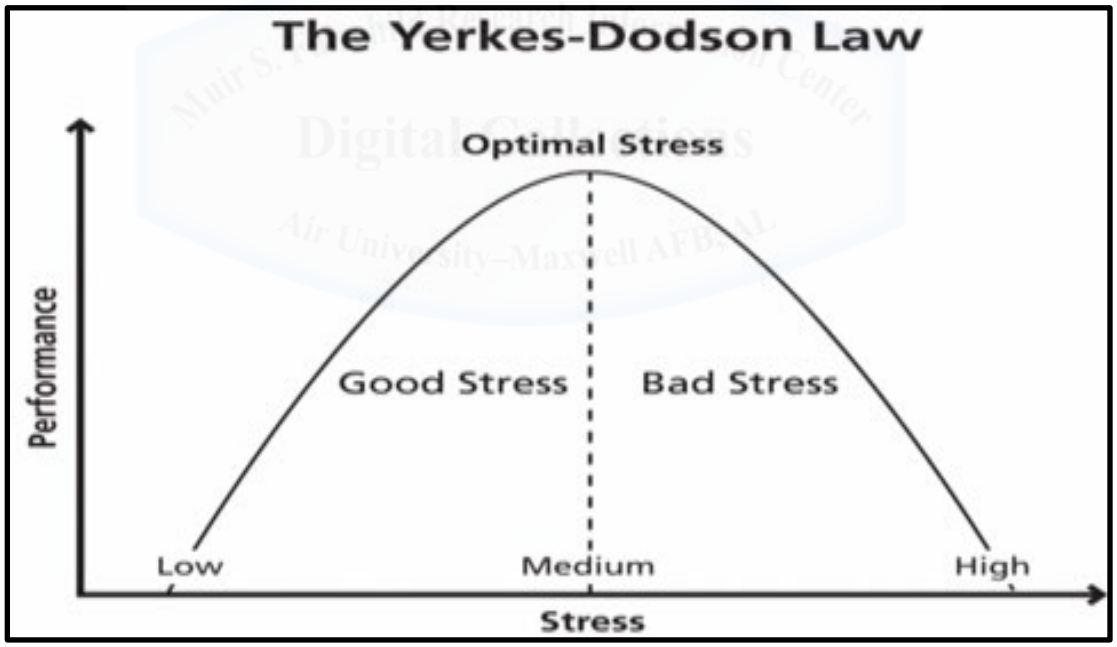

Figure 2: Yerkes-Dodson Curve
Source: Adapted from Joyce Nakatumba-Nabende and Will Aalst's article, "Analyzing Resource Behavior Using Process Mining. Lecture Notes in Business Information Processing." 2009.

[3] Joyce Nakatumba-Nabende and Wil Aalst, "Analyzing Resource Behavior Using Process Mining," vol. 43, 2009, 69–80, https://doi.org/10.1007/978-3-642-12186-9_8.

Variation in Stress

Thomas Steckler defines stress as any challenge to homeostasis that requires adaptive response.[4] It consists of a stimulus input, an evaluation of information, and a response output.[5] Conceptually, the stimulus, or stressor, is a potentially harmful change in environment that occurs and is sensed (evaluated) by an entity.[6] From here, a complex stress response occurs, consisting of an array of physiological, behavioral, cognitive, or emotional factors, which seeks to eliminate or reduce the harmful aspect of the stressor.[7] Other definitions of stress highlight aspects of unpredictability, uncontrollability, and environments where demands exceed regulatory capacity.[8] Finally, stress can vary across time (acute or chronic stress), in intensity, and with its location relative to the task at hand (intrinsic or extrinsic stress).[9] This last factor of stress locale determines how stress affects cognition and information processing, and therefore task performance.

The cognitive effects of stress on memory function and task type

Cognition is an elusive concept but roughly deals with information processing carried out by the brain to generate suitable responses to the environment.[10] Cognition is multidimensional in that it consists of memory, perception, language, and executive function.[11] The effects of stress on cognition, and therefore performance, are determined by the type of memory functions utilized in task performance. Two aspects of memory function are memory types (explicit and implicit memory) and

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[4] Steckler, Kalin, and Reul, *Handbook of Stress and the Brain Part 1*, 25.
[5] Steckler, Kalin, and Reul, 25.
[6] Steckler, Kalin, and Reul, 25.
[7] Steckler, Kalin, and Reul, 26.
[8] Carmen Sandi, "Stress and Cognition," *Wiley Interdisciplinary Reviews: Cognitive Science* 4 (May 1, 2013): 246, https://doi.org/10.1002/wcs.1222.
[9] Sandi, 246.
[10] Sandi, 246.
[11] J. F. Keeler and T. W. Robbins, "Translating Cognition from Animals to Humans," *Biochemical Pharmacology*, Translational Medicine, 81, no. 12 (June 15, 2011): 1356, https://doi.org/10.1016/j.bcp.2010.12.028.

memory operations (working and long-term memory).[12] This study focuses on the differences between explicit and implicit memory functions.

Memory is a complex faculty operating in a multifaceted manner. Larry Squire, a professor of neuroscience and psychology at the University of California, San Diego, notes "The major distinction [in memory] is between the capacity for conscious, declarative (explicit) memory about facts and events, and a collection of unconscious, nondeclarative (implicit) memory abilities, such as skill learning and habit learning."[13] In short, implicit memory function are associated with routine tasks and explicit memory functions are associated with novel tasks. Since organizations and individuals generally face a combination of novel and routine tasks, understanding the effects of stress on performance in both types of task can inform strategies for crisis detection and response.

The negative effect of stress on performance during novel tasks

Building off the interaction between stress and performance in the Yerkes-Dodson curve, Carman Sandi, a behavioral neuroscientist and director of the Brain Mind Institute, concludes that the effects of stress on performance depend primarily on the cognitive process being considered.[14] Specifically, exposure to high stress "chronically impairs performance in explicit memory tasks that require complex, flexible reasoning while improving performance on implicit memory tasks…in well-rehearsed tasks."[15] Two schemes represent these findings and demonstrate a slight revision of the traditional Yerkes-Dodson law

[12] Sandi, "Stress and Cognition," 246.
[13] Larry R. Squire, "Memory and Brain Systems: 1969–2009," *Journal of Neuroscience* 29, no. 41 (October 14, 2009): 12711–16, https://doi.org/10.1523/JNEUROSCI.3575-09.2009.
[14] Sandi, "Stress and Cognition," 255.
[15] Sandi, 255.

mentioned previously (see Figure 3).[16] In these schemes, memory type, stress location and duration are three crucial factors impacting cognitive performance.

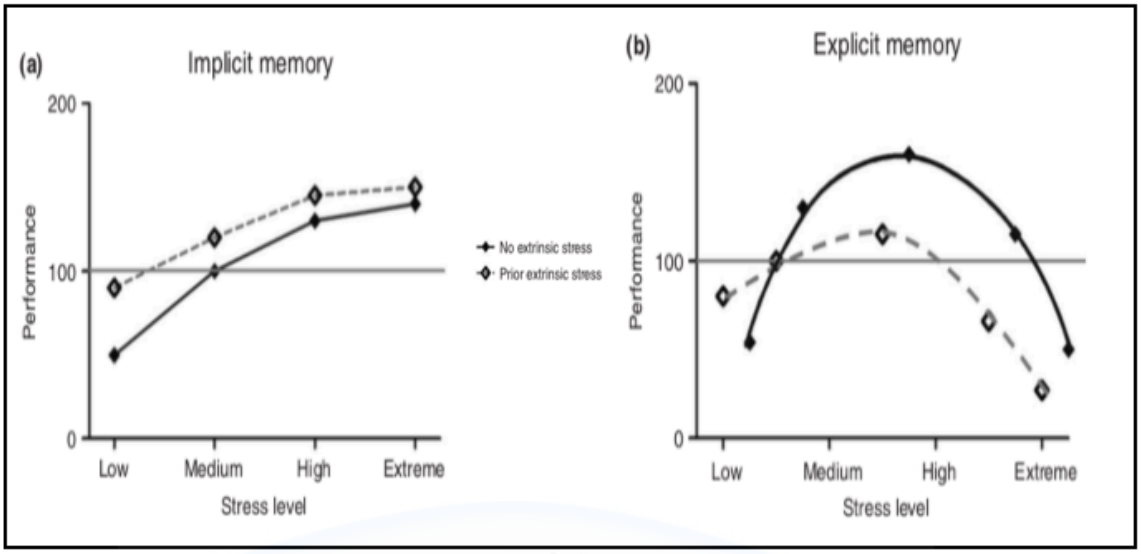

Figure 3: Stress and performance for implicit and explicit tasks
Source: Reprinted from Carmen Sandi "Stress and Cognition" 2013.

The left graph in Figure 3 shows that stress improves performance during implicit memory functions on a linear basis and has diminishing effects with added stress. Furthermore, as stress increases, there is no precipitous performance decrease associated with high levels of stress in this modified Yerkes-Dodson curve. Additionally, the left graph shows any exposure to prior extrinsic stress actually improves cognitive performance. On the other hand, the right graph demonstrates that stress and performance interact on a nonlinear basis (inverted-U-shape) for tasks requiring explicit memory functions. High levels of stress see an exponential decrease in performance. Most interestingly, however, is that any prior exposure to stress lowers the peak cognitive performance capability (shift downward) and lowers the stress threshold required to initiate the performance decrease (shift left).

What this means is that individuals already stressed will perform

[16] Sandi, "Stress and Cognition."

increasingly worse when faced with tasks requiring explicit memory function. In other words, individuals operating under a previous-stressed condition, will perform worse when facing novel tasks. Furthermore, as novel tasks manifest themselves during the evolution of a high-stress crisis, performance will increasingly get worse because of the decreasing stress threshold. Additionally, the relationships between stress and performance outlined above are independent of stress type as both acute and chronic stress improve implicit memory functions and degrade explicit memory functions.[17]

Therefore, contrary to the general Yerkes-Dodson curve, implicit memory performance increases in a linear and asymptotic manner regardless of the duration of stress and the presence of extrinsic stress. In short, from a psychological perspective, cognitive performance in tasks requiring implicit (routine tasks) memory generally improves even if the intensity of the stress increases. However, cognitive performance in tasks requiring explicit memory (novel tasks) follow the Yerkes-Dodson law whereby stress above or below the optimal level decreases performance. This means that task performance requiring hippocampus or prefrontal cortex functions will be greatly diminished under high stress conditions.[18] These include any cognitive tasks associated with executive function such as planning, decision-making, and problem solving – all features required in crisis detection, planning, and response.[19]

The negative effect of stress on performance during routine tasks

Based on the revised Yerkes-Dodson curve in Figure 3, it may appear that stress only degrades cognitive tasks requiring explicit memory functions (novel tasks). Reality, however, is far more complex. Recent research in organizational theory indicates that another phenomenon related to stress can degrade the performance of routine

[17] Sandi, 253.
[18] Sandi, 255.
[19] Gilbert and Burgess, "Executive Function."

tasks. Specifically, large numbers of fast-paced interruptions during routine tasks can overwhelm the coping mechanism of an organization and create an tipping point leading to sudden and nonlinear systematic failure.[20] Jenny Rudolph and Nelson Repenning generated a theory and model that explains how organizations operating within a regulating feedback loop can quickly be transformed into a destabilizing and escalating system by the presence of large and time-varying interruptions to routine tasks.[21]

While this model also rests on general insights from cognitive psychology and the Yerkes-Dodson relationship, its focus is on organizational system dynamics. The central aspect of the theory is the concept of interruptions, which are defined as "any unanticipated event, external to the individual, that temporarily or permanently prevents completion of some organized action, thought sequence, or plan."[22] Furthermore, the interruptions they model are considered organizationally routine, meaning there exists an appropriate response within the organizational framework for resolving each interruption.[23]

All interruptions vary with complexity and difficulty and often require an active mode of thinking.[24] Therefore, in order to incorporate the concept of interruptions and their variation within the theoretical framework, Rudolph and Repenning code interruption "units" based on the cognitive steps required to resolve the interruption and ensure system survival.[25] A model of their theory based on a dynamic Yerkes-Dodson relationship and a series of stocks and flow of interruptions of

[20] Rudolph and Repenning, "Disaster Dynamics."
[21] Rudolph and Repenning.
[22] Rudolph and Repenning, 6.
[23] Rudolph and Repenning, 6.
[24] Meryl Reis Louis and Robert I. Sutton, "Switching Cognitive Gears: From Habits of Mind to Active Thinking," *Human Relations* 44, no. 1 (January 1, 1991): 44, https://doi.org/10.1177/001872679104400104.
[25] Rudolph and Repenning, "Disaster Dynamics," 6.

routine tasks is shown in Figure 4.[26] The theory states that interruptions arrive at a specific rate and accumulate into a pending stock based on the system's interruption resolution rate. The lower the arrival rate or the higher the resolution rate, the less interruptions pending. One important aspect of this model is that it assumes that interruptions never disappear by themselves. Rather they accumulate if left unresolved which increases stress because of the time pressure in the system to resolve the interruptions.[27]

As the quantity of pending interruptions increases, a desired resolution rate emerges given a specific desired resolution time. This desired resolution rate and desired resolution time are emergent characteristics of the organization and the problem it is facing. The relationship between the desired resolution rate and the normal resolution rate conceptualizes the intensity of the stress on the system and where the organization sits on the Yerkes-Dodson curve (see Figure 4. Effectively two different feedback loops operate depending on whether the system is operating on the left or the right sight of the Yerkes-Dodson curve. Simply put, if on the left side of the curve, stress has a balancing function by increasing the desired resolution rate to cope with increased interruptions pending. However, if the stress rises to any point on the right side of the curve, it overwhelms the coping mechanism of the organization. In this case, stress ceases to have a balancing function and becomes a negatively reinforcing function whereby the net resolution rate decreases which in turn increases the interruptions pending. This cycle can continue, if not addressed, until system failure occurs. The key insight from this framework is that the system is nonlinear and has dual feedback loops that are dynamic.[28]

[26] Rudolph and Repenning, 11.
[27] Rudolph and Repenning, 10.
[28] Rudolph and Repenning, 13.

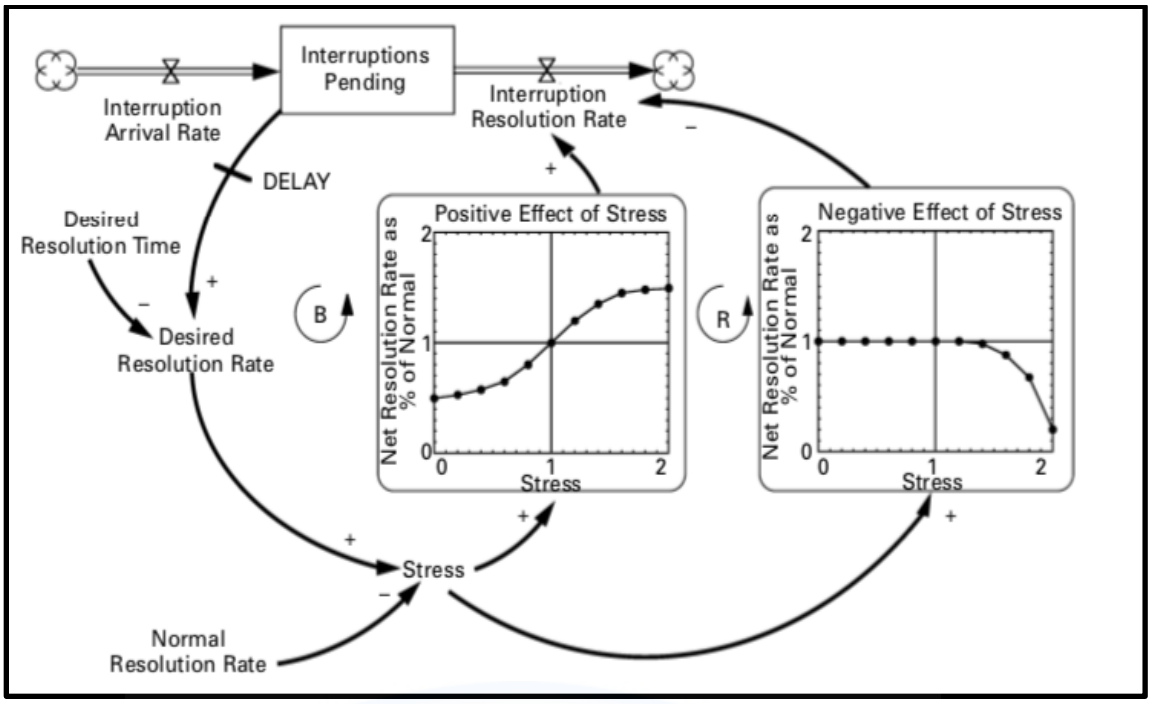

Figure 4: Feedback loops and model structure
Source: Reprinted from Rudolph & Repenning "Disaster Dynamics" 2002.

One result of the nonlinearity in this system is the emergence of a tipping point based on the maximum number of interruptions an organization can handle. This tipping point is where a precipitous drop in net resolution rate occurs and is quickly followed by system collapse (see Figure 5).[29] This is particularly insightful for crisis detection and response. As the system approaches the tipping point (moving from the left side to the right side of the Yerkes-Dodson curve), performance actually increases immediately before the stress feedback loop shifts to become negatively reinforcing (see Figure 3).[30] "As the system approaches its tipping point, the ability to sense its impending disaster is likely to decline."[31] The declining sense of disaster occurs because of the false perception of future increased performance based on previous increased performance. In other words, the organization keeps expanding its capacity to handle interruptions right up to the point of system

[29] Rudolph and Repenning, 16.
[30] Rudolph and Repenning, 16.
[31] Rudolph and Repenning, "Disaster Dynamics."

saturation. This past expansion makes it extremely difficult to sense the imminent tipping point.

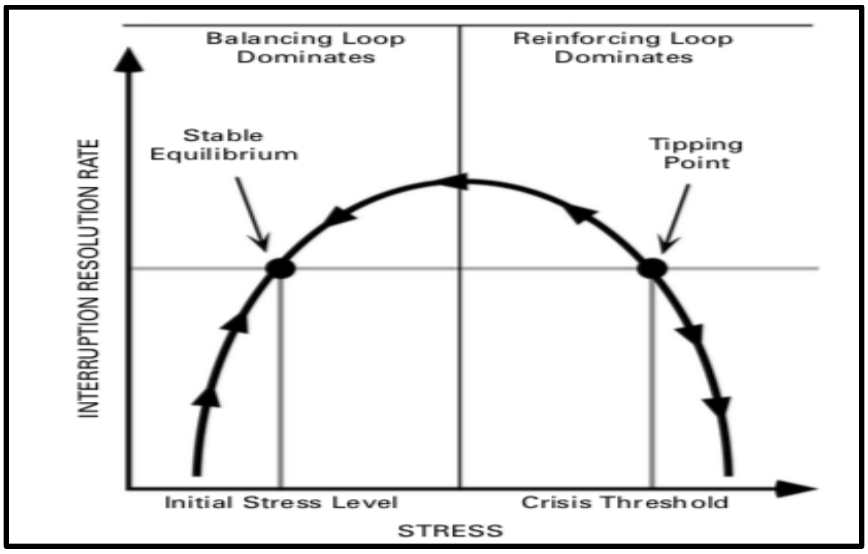

Figure 5: Yerkes-Dodson Curve in Dynamic, Nonlinear Systems
Source: Reprinted from Rudolph & Repenning "Disaster Dynamics" 2002.

An important question to consider is how many interruptions in any given system are required to push the system past the tipping point. The answer has to do largely with the relationship between the net resolution rate and the arrival rate of interruptions.[32] If the system has an excess resolution rate capacity and is operating in an environment with low arrival rates of interruption, the system has the capacity to absorb large variations in the quantity and intensity of the interruptions.[33] This excess capacity, in effect, pushes the equilibrium point and tipping point farther apart on the dynamic Yerkes-Dodson curve depicted in Figure 6. As the resolution and arrival rate converge, the equilibrium and tipping points converge, and the slightest increase in quantity of interruption will push the system past the tipping point (see Figure 5).[34]

[32] Rudolph and Repenning, 21.
[33] Rudolph and Repenning, 21.
[34] Rudolph and Repenning, 22.

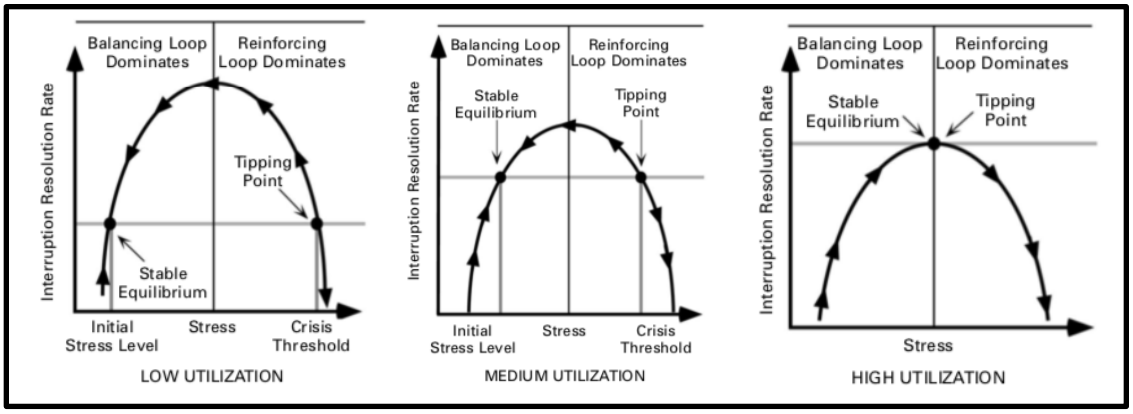

Figure 6: Resource utilization: Function of resolution & arrival rates
Source: Reprinted from Rudolph & Repenning "Disaster Dynamics" 2002.

The effect of stress on performance of routine tasks due to interruptions, and the previously discussed effect on performance of novel tasks (requiring explicit memory) give profound insight into crisis detection, response, and management. These insights include understanding how crises involving novel and routine events may require different approaches to preparation, detection, and management. For instance, crises involving novel problems may stress the resiliency of individuals, groups, and organizations to the degree that they can anticipate such surprising problems.[35] In these types of crises, the established practice is to "step back from the situation at hand, revisit core assumptions, reframe the situation, recombine existing procedures and routines into alternative responses (e.g., improvisation), and engage in some type of higher-order evaluation, such as double-loop learning."[36] This is classic prefrontal cortex cognition utilizing explicit memory functions. While stress can degrade performance in this area of cognition, it is normally not due to the role of time, hence the benefit of stepping back and reconsidering approaches to the problem. While this practice is especially useful when dealing with novel aspects of a crisis,

[35] Karl E. Weick, Kathleen M. Sutcliffe, and David Obstfeld, "Organizing for High Reliability: Processes of Collective Mindfulness.," 1999, 46.
[36] Rudolph and Repenning, "Disaster Dynamics," 25.

they can be deadly for those crises where interruption of routine tasks occurs.

Quantity-induced crises have a different complexity due to their nonlinear dynamics and the difficulty of detecting impending crises. First, as the interruptions accumulate in these crises, individuals, groups, and organizations may increase their productivity to diminish the accumulation of interruptions that are pending.[37] This powerful dynamic reinforces the idea that continually increasing productivity will produce higher efficiency.[38] However, it only applies on the left side of the tipping point on dynamic Yerkes-Dodson curves. This cognitive bias can blind individuals, groups, and organizations from detecting an impending crisis because it reinforces a 'business as usual' approach to a complex event. Second, once organizations approach the tipping point and encounter the negative reinforcing feedback loop, they may be tempted to implement a new approach to problem solving. Yet, any time taken to reframe the crises reduces the net resolution rate of interruptions and increases the accumulation rate of interruptions. This may be enough to push the system past the tipping point and into systematic failure.[39] Therefore, quantity-induced crises impair crisis detection and can be exacerbated by the 'taking a step back" approach common in novel crises. A different strategy is required to handle the challenge of quantity-induced crises.

What may be required in quantity-induced crises is a strict adherence to established procedures while employing escape strategies to diminish the accumulation rate.[40] This dynamic plays out in an array of activities especially those conducted by HROs.[41] For instance, Rudolph and Repenning point to the way Mount Everest summit organizations

[37] Rudolph and Repenning, 25.
[38] Rudolph and Repenning, 25.
[39] Rudolph and Repenning, 25.
[40] Rudolph and Repenning, 25.
[41] Perrow, *Normal Accidents Living with High-Risk Technologies*.

adhere to strict turnaround procedures on the day of the final summit especially in light of the many interruptions that occur, which threaten the life of climbers.[42] Other organizations like aircraft carriers, emergency rooms, and air traffic control centers employ a similar strategy.

While the research on the relationship between stress and performance is far from complete, previous studies show powerful incentives to bolster organizational capacity for crisis detection and response. This is particularly true when one considers the complexity facing decision-makers in crises involving routine *and* novel events. The interactive nature of stress and performance requires organizations to consider how they can bolster their resiliency and adaptive capacity to handle disruptive changes. This paper offers the following framework for understanding how disruptive change, stress, and performance interact together to produce a crisis cycle (see Figure 7). Furthermore, it conceptualizes how organizational resiliency can influence the crisis cycle pathway by opening off ramps at specific resiliency points (A,B,C,D) which ultimately improves the adaptive capacity of these organizations.

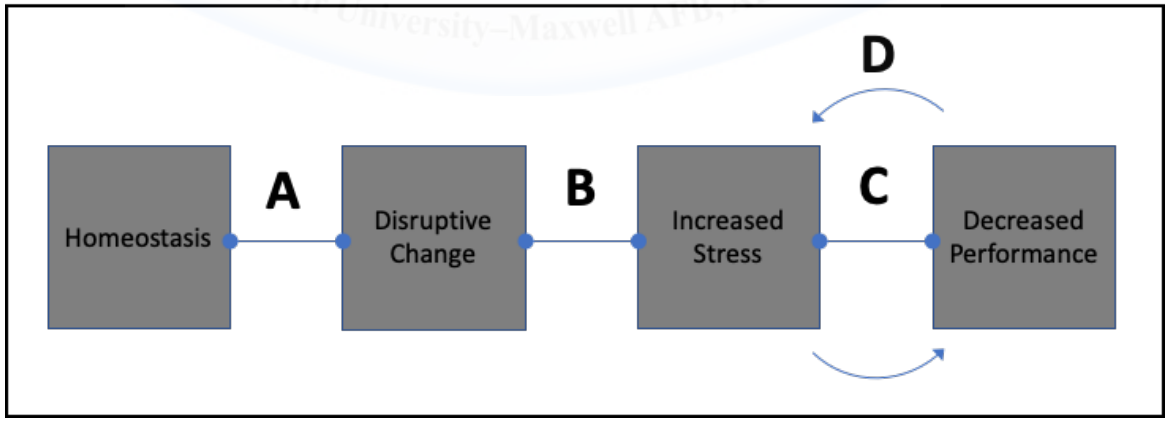

Figure 7: Crisis Cycle Framework
Source: Author's Original Work

The crisis cycle illustrated above begins with an organization at a certain level of homeostasis relative to its environment. If enough stress is generated by disruptions, then routine and novel task performance

[42] Rudolph and Repenning, "Disaster Dynamics," 26.

decreases. This performance decrease creates a negatively reinforcing feedback loop which may push the organization into crisis if not mitigated. Improving organizational resiliency offers a mechanism to improve crisis detection and increase adaptability during the crisis cycle in at least four ways.

Fist, organizational resiliency can expand the organizations capacity to anticipate future disruptions (Point A) or navigate the fitness landscape to avoid catastrophic valleys due to impending disruptions. Second, improving resiliency can lower the level of stress generated from any given disruption (Point B). Third, if disruptions from homeostasis increase stress significantly, high degrees of organizational resiliency can decrease the negative effect of stress on the performance of routine and novel tasks (Point C). Finally, a robust level of organizational resiliency can help organizations break the recursive feedback loop that feeds the crisis cycle (Point D). Therefore, considering that the environment is constantly changing, any one of these benefits provides an organization with an improved adaptive capacity to handle disruptive change. In short, organizational resiliency provides a mechanism to detect and adapt to incoming disruptions from the internal and external environment. An in-depth analysis of organizational resiliency and the way leaders can foster it are the subjects of Chapter Three.

Chapter 3
Organizational Resiliency

Chapter One and Two developed a framework on how crises can develop through the interaction between disruptive changes, stress, and performance. In this framework, certain internal or external changes disrupt the organization from a state of homeostasis. These changes produce stress on a system or organization relative to the actual or perceived threat to their continued existence or functionality. If the stress from these disruptive changes reaches a high enough level, then organization performance in both routine and novel tasks can decrease precipitously. The performance decrease may act as a dynamic feedback loop ultimately producing a crisis due to failure of functionality, existence, or reputation, depending on the degree of task performance degradation. This chapter lays out organizational resiliency as a mechanism for anticipating disruptive changes, managing stress through perceptions of changes, and mitigating the negative effects of the disruption-stress-performance interaction process that result from disruptive changes. In other words, this chapter explains how organizational resiliency can offramps at the four resiliency points (A,B,C,D) in the crisis cycle by providing an adaptive capacity for the organization (see Figure 7).

This chapter articulates organizational resiliency in two sections. Section one unpacks the principle challenge to being organizationally resilient as it relates to crisis sensing and crisis management. This section offers critical insights from complexity theory about how disruptive change affects traditional notions of stability and strategies, or choices. Section two builds upon the foundation of complexity theory by describing the nature of organizational resiliency. This section explains how organizational resiliency concepts developed, describes the ingredients that contribute to high levels of organizational resiliency, and

explain why it is a requirement for navigating the modern world. Drawing upon multiple concepts and disciplines, this paper defines organizational resiliency as **an organization's adaptive capacity to anticipate, absorb, respond to, and capitalize on specific disruptive changes that threaten the functionality or survival of the organization.** Stronger organizational resiliency allows an organization to maneuver in a dynamic fitness landscape, rapidly shift priorities and resource allocation, and ultimately capitalize on the disruptive changes to maintain a comparative advantage. Finally, a high degree of organizational resiliency requires a balancing of adaptability and brittleness to best preserve the values and priorities of the organization. Organizational resiliency embraces the notion of graceful extensibility which is the adaptive capacity to continue to operate at diminished organizational capacity while maneuvering the organization away from areas of brittleness through resource transference.[1]

Section 1: Change, Uncertainty, and Fitness

At the heart of organizational resiliency are the concepts of change and complexity. Shona Brown and Kathleen Eisenhardt, in their seminal book *Competing on the Edge,* argue that managing change is the central strategic challenge today.[2] This is due, in part, to the increasing complexity of the world and the human tendency to seek equilibrium over change.[3] However, while the world may be more interconnected and interdependent today than in previous eras, managing disruptive change has been an enduring challenge throughout the ages. Napoleon's *levee en masse*, machine guns and tanks in World War I, the airplane in World War II, the space race during the Cold War, and the global internet and communications technology of the modern age, are all examples of social

[1] Woods, *Complexity: Advancing the State of Thought and Practice Across Navy, DOD, and the Federal Government.*
[2] Shona L. Brown and Kathleen M. Eisenhardt, *Competing on the Edge: Strategy as Structured Chaos* (Harvard Business Press, 1998), 4.
[3] Brown and Eisenhardt, *Competing on the Edge.*

and physical technologies that presented or resulted from disruptive changes to organizations and systems.

Understanding why these changes occur is critical for leaders of socio-technical organizations like the typical Air Force operational squadron. A socio-technical organization consists of a system of systems with technical, human, and organizational features.[4] A system of systems contain several common characteristics: operational and managerial independence of elements; evolutionary development and the existence of emergent behavior; and some distributed nature of the elements.[5] The reality of disruptive changes in these systems exists because of the inherent complexity of these organizations.

Dr. David Woods, one of the founders of the field of resiliency engineering, describes the complexity of the world as an environment that is constantly changing, which requires systems and organizations to adapt if they are to survive.[6] These adaptations, in turn, change the environment in which they act, creating a dynamic and multidimensional cycle. In other words, the universe is one big complex adaptive system containing multiple smaller scale complex adaptive systems interacting together. The reality of complexity is crucial to the concept of organizational resiliency. However, it is important to note that there is no unified theory of complexity. Instead, several different disciplines have contributed to produce three broad schools of thought on complexity.[7]

This study will draw upon the complexity-based thinking school which recognizes that the rapidly changing environment and places significant limitations on what exact knowledge we can have of any given

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[4] Don Harris and Neville A. Stanton, "Aviation as a System of Systems: Preface to the Special Issue of Human Factors in Aviation," *Ergonomics* 53, no. 2 (February 2010): 145–48, https://doi.org/10.1080/00140130903521587.
[5] Harris and Stanton.
[6] David Woods, *Complexity: Advancing the State of Thought and Practice Across Navy, DOD, and the Federal Government* (Naval Surface Warfare Center: Carderock Division, 2019), https://www.youtube.com/watch?v=KJJ2NCjc2Wg&amp=&index=4.
[7] Gilpin and Murphy, *Crisis Management in a Complex World*, 33.

phenomenon. From a social perspective, complexity thinking focuses on many individual actors who interact locally, adapt to their immediate situations, and form unpredictable population level patterns.[8] From a systems perspective, complexity thinking focuses on high degrees of non-linear interactions between actors or entities.[9] These two definitional insights help explicate the social and technical complex systems that make up modern socio-technical organizations.

Socio-technical complex adaptive systems have seven features.[10] First, complex systems are composed of individual actors. Second, the interactions of these actors are nonlinear, recurring, local, and adaptive. These interactions change the system over time as new strategies emerge. Third, actors exhibit the principle of self-organization. Fourth, a complex system exhibits instability due to constant evolution. In fact, stability is never achieved otherwise the system would cease to change, and thereby cease to be complex. Fifth, complex systems are dynamic and are extremely sensitive to initial conditions and the past interactions of the actors. Sixth, complex systems have ill-defined boundaries meaning there is no concrete bifurcation between the environment and the system. Rather, the two form a permeable border. Finally, complex systems are irreducible, meaning they are not merely the sum of all the subparts. In this way, complex systems are qualitatively different than merely complicated systems. In complex systems, analyzing the individual parts will miss key emergent and group dynamics.[11] A good example of complex adaptive systems are social networks, governments, traffic flow, hospital operations, and weather systems to name a few.

Complexity-thinking contributes three key insights regarding the

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[8] Priscilla Murphy, "Symmetry, Contingency, Complexity: Accommodating Uncertainty in Public Relations Theory," *Public Relations Review* 26, no. 4 (2000): 450.
[9] Kurt Richardson and Paul Cilliers, "What Is Complexity Science? A View from Different Directions," 2001, 8.
[10] Gilpin and Murphy, *Crisis Management in a Complex World.*
[11] Gilpin and Murphy, 24–32.

reality of change as it relates to organizational resiliency. First, the interdependence and the evolving nature of interactions means that there will always be hidden or unrecognized connections between actors or entities. These hidden connections mean that any models of the system, regardless of the quantity of data available, will be at best incomplete.[12] Therefore, decision-makers must constantly revise or update their models and resist getting stuck in a sense of settled comprehension of a given phenomenon.

Second, the seven characteristics of complex systems generate emergent dynamics at the population level which affect both the system and the environment. In other words, there are rules of sorts, which govern the system, but these rules are not linear, Newtonian, or fixed. Local level conditions generate the constraints that form dynamic rules based on evolving interactions between actors.[13]

Third, any socio-technological organization or system will seem disordered or chaotic because of limited resources, conflicting goals and values, and the presence of disruptive changes. Handling the disruptive changes will rarely go according to plan and there will be a temptation to blame the organization or people instead of the more difficult task of assessing the adaptive capacity of the organization.[14]

The reality of continuous disruptive change is further exacerbated when one considers the uncertainty associated with the direction and timescale of change. Adapting to a disruptive change originating in a known timescale and direction is difficult enough. Adapting to an unknown change is a qualitatively different challenge. Fitness landscapes help conceptualize this troubling dimension of change. A fitness landscape, sometimes called an adaptive landscape, is a conceptual

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[12] Woods, *Complexity: Advancing the State of Thought and Practice Across Navy, DOD, and the Federal Government.*

[13] Gilpin and Murphy, *Crisis Management in a Complex World*, 26.

[14] Woods, *Complexity: Advancing the State of Thought and Practice Across Navy, DOD, and the Federal Government.*

framework with origins in evolutionary biology but used throughout the social sciences (see Figure 8).[15]

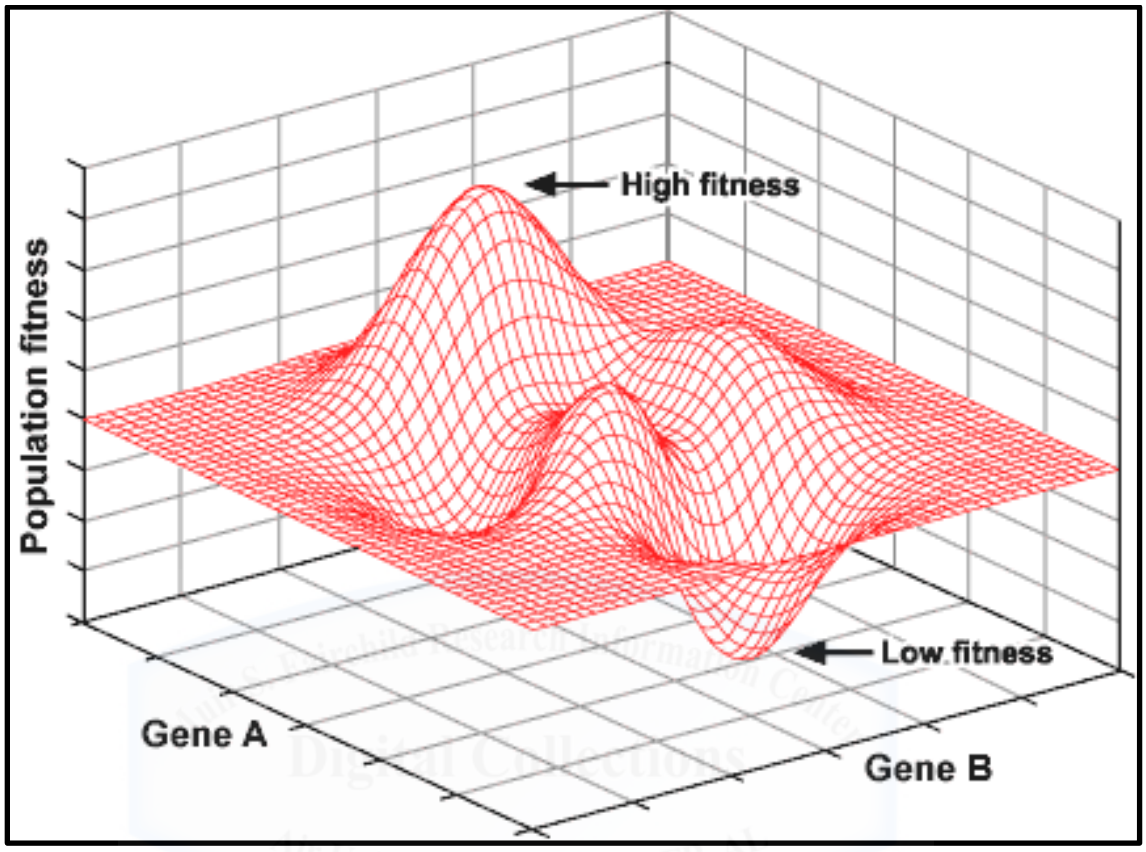

Figure 8: Example Fitness Landscape
Source: Reprinted from Gerrits and Mark "The Evolution of Wright's (1932) Adaptive Field to Contemporary Interpretations and Uses of Fitness Landscapes in the Social Sciences" 2015.

These landscapes are three-dimensional diagrams that look like a series of mountains and valleys that help make sense of evolutionary or innovation changes in a complex system. Since evolutionary changes happen in an unpredictable manner, these diagrams show high-fitness solutions, choices, or strategies as mountain peaks in contrast to lower fitness plains and valleys. However, reality is even more complex.

The real-world fitness landscapes seek to represent is multidimensional and dynamic with respect to time and the interactions

[15] Lasse Gerrits and Peter Marks, "The Evolution of Wright's (1932) Adaptive Field to Contemporary Interpretations and Uses of Fitness Landscapes in the Social Sciences," *Biology & Philosophy* 30, no. 4 (2015): 459–479.

within the ecosystem. Because the presence and value of opportunities is always shifting, the mountains and valleys of the landscape also shift as the system changes. This dynamic nature makes it incredibly difficult to predict where and when the next peak will emerge. Moreover, a high-fitness solution that allows an actor to scale a peak today may turn into a valley tomorrow when the system changes.

A classic example of a fitness landscape from evolutionary biology is the landscape that describes the size of beaks in Galapagos finches. As seed sizes increased on the islands, finches with large enough beaks to eat big seeds would find themselves atop a conceptual fitness peak. When new plants with smaller seeds began to grow, birds with more dexterous, smaller beaks previously occupying a fitness valley began to ascend a new, emerging fitness peak.[16]

A military example of the problematic uncertainty in disruptive changes is the failure of the Maginot Line in France. This defensive fortification was built upon trench warfare concepts of World War I. In other words, it was an adaptive solution representing a high fitness peak in the evolutionary landscape of World War I. However, by World War II, mechanized warfare had turned that peak into a valley which then created a disastrous disruptive challenge for the French. While it is debatable on whether the French should have had better foresight into the timing of World War II or should have sensed the directional change of warfare from trench to mechanized, this example proves the dangers and difficulty of dealing with continuous and uncertain changes in a complex adaptive system.

A more modern military application of uncertainty and fitness landscape could be the use of large regional airbases such as Prince Sultan Air Base, Saudi Arabia, to project airpower during OPERATIONS Desert Storm, Enduring Freedom, Iraqi Freedom and Inherent Resolve.

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[16] Erik Svensson and Ryan Calsbeek, *The Adaptive Landscape in Evolutionary Biology* (Oxford University Press, 2012), 182–83.

The diplomatic relationships with host nations, logistical supply chains and depots, and large manpower and equipment footprints were among several factors contributing to the landscape of airpower projection during this period of history. While large regional bases have proven to be high fitness peaks in today's environment, disruptive changes in the form of anti-access/area denial capabilities, hypersonic weapons, and small unmanned aerial systems are likely to transform that high fitness peak into plain or valley. Since these airbases are just one part of a complex adaptive system used to generate airpower, the 2nd and 3rd order effects may require significant adaptation in airpower doctrine and strategy. Exploring swarm technologies, miniaturized weapons advancements, space-based capabilities, subsurface capabilities, rapid resupply via space, and cyber effects may be a few of the adaptive solutions that enable airpower to climb an emerging peak in the changing fitness landscape.

In summary, the starting point for understanding organizational resiliency is coming to grips with the reality of uncertain and continuous changes in the fitness landscape all of which threaten to disrupt organizations that do not possess adequate adaptive capacity. These disruptive changes are not abnormal, easily predictable, or linear. Rather than being surprised when they occur, the status quo should be a state of expecting unpredictable and nonlinear disruptive changes. Moreover, organizations should be organized, resourced, and built upon a culture that values adaptability over equilibrium. In other words, a culture that has a high degree of organizational resiliency. It is what a dynamic fitness landscape demands in order to survive.

Section 2: Organizational Resiliency and Complexity

Organizational resiliency is a relatively recent development in management theory and draws on key insights from multiple disciplines. This paper integrates multiple concepts of organizational resiliency to define it as an organization's adaptive capacity to anticipate, absorb,

respond to, and act to capitalize on specific disruptive changes that threaten the functionality or survival of the organization. High degrees of organizational resiliency allow an organization to maneuver in a dynamic fitness landscape, rapidly shift priorities and resource allocation, and ultimately capitalize on the disruptive changes to maintain a comparative advantage. Finally, high degrees of organizational resiliency require balancing robustness and brittleness in a way that supports key values and priorities of the organization at any given moment.

The modern conceptualization of organization resiliency is formed from different disciplines including engineering, business strategy, culture studies, organizational theory, supply chain studies, organizational learning, and the wider social sciences.[17] Several scholars argue that organizational resiliency has developed through five different research efforts. The first effort emerged in the early 1980's and focused on resiliency as a response to threats.[18] In the aftermath of large-scale accidents like the Space Shuttle Challenger or Chernobyl accidents, the second effort saw resiliency as reliability.[19] The third effort connected resiliency to individuals and was grounded in psychology.[20] The fourth and fifth efforts described resiliency as organizational adaptation to the external environment and the complexity of the interactions between organizations respectively.[21]

Despite varying research focus, three themes regarding managing disruptive changes endure throughout the literature. First, organizational resiliency literature questions the notion the leaders can use their position, expertise, or planning to completely forecast or control

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[17] Thomas Andersson et al., "Building Traits for Organizational Resilience through Balancing Organizational Structures," *Scandinavian Journal of Management* 35, no. 1 (March 1, 2019): 37, https://doi.org/10.1016/j.scaman.2019.01.001.
[18] Andersson et al., "Building Traits for Organizational Resilience through Balancing Organizational Structures."
[19] Andersson et al.
[20] Andersson et al.
[21] Andersson et al.

future disruptive changes.[22] Second, informal characteristics of organizations like culture, values, learning, and processes are more crucial to high degrees of organizational resiliency than formal characteristics.[23] Third, organizations cannot simultaneously be resilient against every change due to finite resources and conflicting values.[24] Instead, organizational resiliency is a balance between being robust and brittle, or fragile.[25] The key to resiliency is knowing where brittleness exists in an organization's operating envelope and then having the capacity to maneuver it as the fitness landscape changes.[26] This capacity often involves changing priorities, resource allocation, and structure as the landscape changes. Most importantly, it is both people and culture that enable this maneuverability to exist. This is the adaptive capacity which is at the heart of organizational resiliency.

The 2003 Space Shuttle Columbia disaster at National Aeronautics and Space Administration (NASA) serves as an example of previous three themes. The opening pages of the executive summary of the accident investigation board report note that management practices, intense pressure to stay on timeline, and inadequate safety assessment contributed significantly to the crash.[27] The report goes on to state,

> The Board presents its view that NASA's organizational culture had as much to do with this accident as foam did. By examining safety history, organizational theory, best business

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[22] Martina K. Linnenluecke, "Resilience in Business and Management Research: A Review of Influential Publications and a Research Agenda," *International Journal of Management Reviews* 19, no. 1 (2017): 4–30.
[23] Andersson et al., "Building Traits for Organizational Resilience through Balancing Organizational Structures."
[24] Woods, *Complexity: Advancing the State of Thought and Practice Across Navy, DOD, and the Federal Government*.
[25] Andersson et al., "Building Traits for Organizational Resilience through Balancing Organizational Structures."
[26] Woods, *Complexity: Advancing the State of Thought and Practice Across Navy, DOD, and the Federal Government*.
[27] Harold W. Gehman, *Columbia Accident Investigation Board Report*, vol. 6 (Columbia Accident Investigation Board, 2003), 12.

> practices, and current safety failures, the report notes that only significant structural changes to NASA's organizational culture will enable it to succeed. The Board concludes that NASA's current organization does not provide effective checks and balances, does not have an independent safety program, and has not demonstrated the characteristics of a learning organization.[28]

Culture, learning, and organizational history significantly contributed to NASA's inability to prevent a crisis due to disruption.

The foam strike represented a disruption both in novel and routine tasks. It was novel disruption in that it occurred in an operating envelope (65,000 feet at Mach 2.46) unlike previous strikes. However, it was a routine disruption that became one of many disruptions in the quest to get the International Space Station back on schedule.[29] This example demonstrates the complexity of how just one disruption (foam strike) can develop into a crisis. Had NASA a higher degree of organizational resiliency, perhaps the outcome would have been different. But what exactly is organizational resiliency? More importantly, what are the organizational drivers and characteristics that create a high degree of organizational resiliency for socio-technical organizations like NASA and Air Force operational squadrons?

Dr. Epaminondas Koronis and Dr. Stavros Ponis, two business and engineering researchers, offer a framework for organizational resiliency that draws on the previous five streams of research. They argue three cultural characteristics and four organizational drivers enable high degrees of organizational resiliency (see Figure 9).[30]

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[28] Gehman, *Columbia Accident Investigation Board Report*.

[29] Gehman.

[30] Epaminondas Koronis and Stavros Ponis, "Better than before: The Resilient Organization in Crisis Mode," *Journal of Business Strategy* 39, no. 1 (January 1, 2018): 32–42, https://doi.org/10.1108/JBS-10-2016-0124.

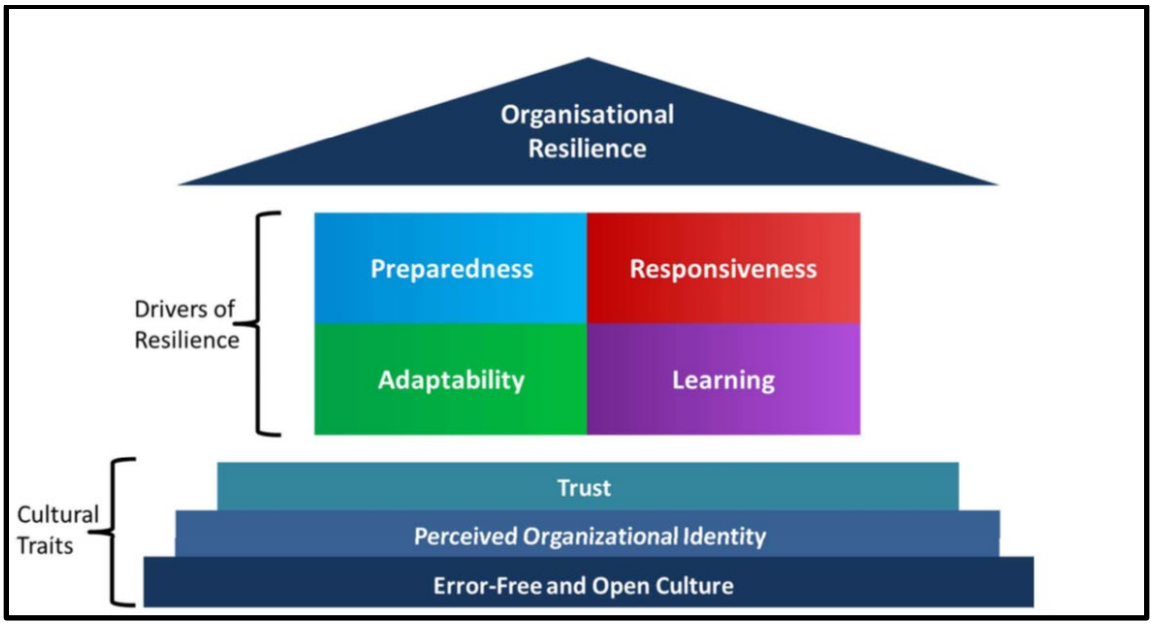

Figure 9: Framework of Organizational Resiliency
Source: Reprinted from Koronis and Ponis "The Resilient Organization in Crisis Mode," 2018.

The three cultural characteristics are a perceived organizational identity, trust, and an open and error-free culture. Together, these three characteristics are the critical human and social capital that mark highly resilient organization. High degrees of social trust, values, and open engagement are important because anticipating and responding to disruptive changes involve both rational and emotional responses. This principle is illustrated in the different responses American airline companies took in the immediate aftermath of the 9/11 attacks.

Southwest Airlines had long maintained a culture with a distinct organizational identity and high levels of trust and communications with its employees. Yet, despite significant financial risk and losses in the months after the attacks, Southwest refused to engage in layoffs to handle the disruption in air travel. Compare this response to that of Northwest Airlines or US Airways which had cultural problems between employees and executives for years leading up to the attacks. They responded in accordance with cultural values and initiated large segments of layoffs. Fast forward four years and Southwest Airlines had

outperformed all the other airlines and recovered to their pre-9/11 value while Northwest and US Airways had ceased to exist.[31] The airlines' varying degrees of resiliency in the face of the disruptive 9/11 attack is attributed, in part, to their cultural characteristics.

Beyond three cultural traits, however, organizational resiliency is built on four different drivers: preparedness, responsiveness, adaptability, and learning. These four drivers impact crisis detection and response. Preparedness is about more than having a crisis action plan on the shelf known only to a centralized team. As Koronis and Ponis point out, it involves multiple levels of activity, including "resources (building buffers and alternative resources), functions (crisis planning and setting procedures) and training all people and leaders."[32] One example of this degree of preparedness in the Air Force is EXERCISE Rapid Forge.

Rapid Forge was an expeditionary training exercise conducted in 2019 providing assurance to NATO allies and practicing agile combat operations in a distributed manner. The 4th Fighter Wing deployed a complete command and control section to operate F-15E and F-35 squadrons in a distributed manner throughout Europe. Not only did this involve planning for future disruptive changes, but it also involved developing the concept of multifunction Airmen. These Airmen, normally specialists in fuel, weapons, or communications, were cross trained to perform multiple function in the advent of complex and distributed operations This exercise developed alternative resources, set new procedures for agile combat operations, and ensured training and planning were known by all personnel in the organization.[33]

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[31] Jody Hoffer Gittell et al., "Relationships, Layoffs, and Organizational Resilience: Airline Industry Responses to September 11," *The Journal of Applied Behavioral Science* 42, no. 3 (September 1, 2006): 300–329, https://doi.org/10.1177/0021886306286466.
[32] Koronis and Ponis, "Better than Before."
[33] Spangdahlem Air Base Public Affairs, "Operation Rapid Forge Concludes," U.S. Air Force, July 28, 2019, https://www.af.mil/News/Article-

Preparing a plan is a good start but the complexity of disruptive changes requires a degree of responsiveness when managing crises. This driver of organizational resiliency involves a timely and adaptive response through the activation of informal networks, ideas, and processes.[34] Responsiveness is distinct from preparedness because it can exist even if the organizations is unprepared. For example, in response to Hurricane Katrina, Walmart mobilized unprepared supply chains and made unprepared decision to support recovery efforts demonstrating a high degree of responsiveness.[35]

In addition to preparedness and responsiveness, organizational resiliency requires adaptability. Adaptability involves rejecting the notion that effective crisis management results in returning to a pre-crisis condition where structural and process reforms take place to prevent a similar crisis from reoccurring.[36] Instead, adaptability is about growing a dynamic capacity to maintain resources that are flexible, storable, convertible, and malleable enough to capitalize on unexpected changes.[37] This capacity grows over time and enables organizations to outmaneuver what Dr. Woods labels "complexity penalties," which are the costs of disruptive changes.[38] This capacity is highly dependent on human capital being empowered to engage in creative solutions.[39] An example of this driver is Toyota's adaptive response to the disastrous earthquake in Japan in 2011 which effected several crucial production plants. Through creative solutions, Toyota was able to outmaneuver complexity penalties in production and manufacturing by engaging

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Display/Article/1918143/operation-rapid-forge-concludes/.

[34] Koronis and Ponis, "Better than Before."

[35] Koronis and Ponis.

[36] Koronis and Ponis.

[37] Koronis and Ponis.

[38] Woods, *Complexity: Advancing the State of Thought and Practice Across Navy, DOD, and the Federal Government.*

[39] Koronis and Ponis, "Better than Before."

global supply chains and adapting production processes.[40]

The fourth, and final, driver of organizational resiliency is a thorough learning process. This driver affects the ability to sense emerging disruptive changes, draw meaning from what these changes mean for the future, and adapt to these changes. In other words, learning processes influences the entire disruption-stress-performance cycle. Learning processes involve absorbing internal and external knowledge, making accurate assessments of risk and decision-space, and having a willingness to change.[41] Organizations with strong learning capacities are willing to experiment in order to test emergent peaks in the fitness landscape and are not afraid to change policies, rules, objectives, or values. Organizations with a learning process are eager to draw lessons learned, yet do not settle for simple explanations of complex phenomena. Moreover, they can distinguish whether mistakes are a result of rule or skill deficiencies.[42] Finally, learning reinvigorates new levels of preparedness, responsiveness, and adaptability. This new knowledge informs the future and facilitates crisis detection networks.[43] Apple Computers is widely considered a company with a good learning process. The learning process established by Steve Jobs in the form of Apple University ensures critical lessons learned throughout Apple's history are inculcated in the workforce.

In conclusion, disruptive change is a normal output of complex adaptive systems that mark the operating environment of socio-technical organizations like Air Force squadrons. These disruptive changes can be understood as dynamic changes in the fitness landscape. Moreover, these disruptive changes are exceedingly difficult to predict, in terms of direction and timescale. Organizational resiliency,

[40] Koronis and Ponis.
[41] Koronis and Ponis.
[42] Koronis and Ponis.
[43] Koronis and Ponis.

however, is an adaptive capacity that enables an organization to anticipate, absorb, and act to capitalize on the specific disruptive changes that threaten the functionality or survival of the organization.

The degree of resiliency in each organization is a function of three cultural characteristics that serve as a foundation for four drivers of organizational resiliency. A high degree of resiliency creates organizational capacities that are flexible, storable, convertible, and malleable, i.e., capacities that are adaptable. Strong resiliency allows the organization to maneuver in the face of complexity penalties by shifting areas of brittleness and robustness relative to the dynamic operating environment. Organizational resiliency generates this maneuverability by influencing the disruption-stress-performance cycle at the four resiliency points (A, B, C, D).

Chapter Four explores this interaction in greater detail for both routine and novel tasks disruptions by applying the framework of organizational resiliency developed in this study to the crisis involving the mistaken shoot down of Iran Air Flight 655 by the USS VINCENNES in 1988.

Chapter 4

Applying Organizational Resiliency: The Downing of Iran Flight 655 by the USS VINCENNES

Chapter One and Two laid the groundwork for thinking about crises as disruptive changes that threaten the continued functionality or existence of organizations. While the scope of crises is vast, Chapter Two bounded the analysis to those crises that result from continuous interruptions of routine tasks or the sudden appearance of a novel task. These disruptive changes generate stress on individuals and organizations which can have a negative effect on the performance of these routine and novel tasks. In certain cases, this stress may reach a level where a dynamic feedback loop pushes the organization beyond a tipping point. This chapter applies the concepts of organizational resiliency developed in Chapter Three to a specific case study involving the mistaken shoot down of Iran Air Flight 655 in 1988 by the USS VINCENNES.

Organizational resiliency, consisting of three cultural traits and four organizational drivers, strengthens the adaptive capacity of the organization and enables it to maneuver in a changing fitness landscape. Figure 101 reviews how organizational resiliency can influence the crisis cycle to sense and avoid impending disruptive changes (Point A), absorb unavoidable disruptive changes (Point B), respond effectively to disruptive changes (Point C), and mitigate the negative feedback effects of stress and performance (Point D).

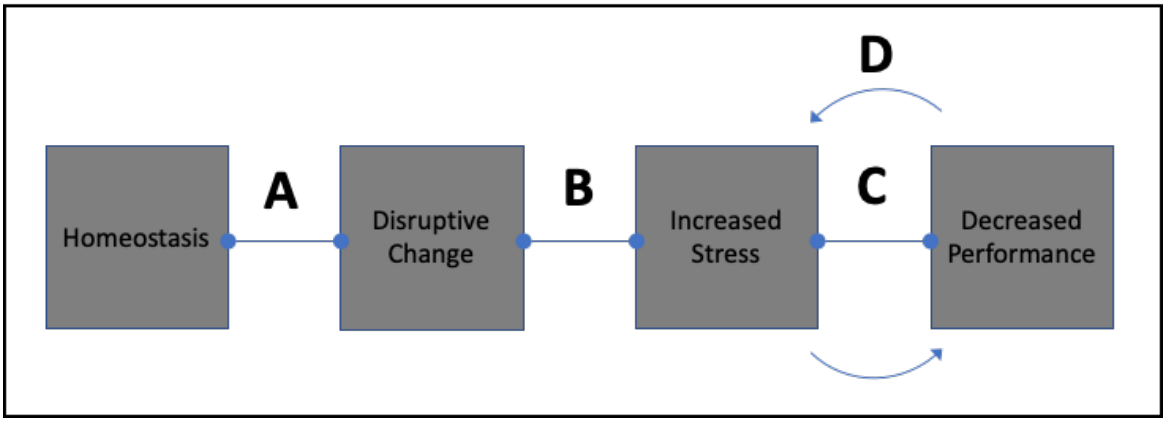

Figure 10: Crisis Cycle Framework
Source: Author's Original Work

This chapter explores how organizational resiliency may act upon an organization's pathway through crisis by influencing the change-stress-performance cycle at four key resiliency points. It is important to keep in mind that organizational resiliency does not work simply in a linear or mechanistic manner despite how its presented in the framework. Nor can organizational resiliency guarantee organizational survival or completely remove the negative effects of disruptive changes. Rather, organizational resiliency is a key factor in generating what Dr. David Woods calls graceful extensibility – the adaptive capacity to continue to operate at diminished organizational capacity while maneuvering the organization away from areas of brittleness through resource transference.[1]

This chapter has two sections. Section one begins with a case study summary of the mistaken shoot down of Iranian Air Flight 655 by the USS VINCENNES on July 1988 during the Iran-Iraq war. This case study serves as fertile ground to consider the principles of organizational resiliency as they relate to disruptive changes. Section two analyzes the USS VINCENNES' brittleness to handle a perceived air threat posed by an airliner. Next, this section considers how the four organizational

[1] Woods, *Complexity: Advancing the State of Thought and Practice Across Navy, DOD, and the Federal Government.*

drivers may have provided off ramps in the crisis cycle during the six-minute period of extreme time compression and uncertainty.

Section 1: Navy USS VINCENNES Iranian Airline Shoot Down

On 3 July 1988 in the span of seven minutes, the Aegis guided missile cruiser USS VINCENNES detected, tracked, and mistakenly engaged Iran Air Flight 655 with two Surface to Air Standard Missiles resulting in the tragic death of 290 civilians. This tragedy was a disastrous crisis involving a complex set of disruptions including a dynamic sea battle, congested and ambiguous airspace, malfunctioning equipment, and a host of intense human factors affecting the crew. The commanding officer, Captain William C. Rogers III, faced several disruptive changes which generated considerable stress and degraded his ship's performance of a series of routine and novel tasks.

The following account and analysis are taken from the Formal Investigation conducted by the Department of Defense (DOD) and Central Command (CENTCOM) following the shoot down. The use of this case study serves to illuminate how organizational resiliency may increase the adaptive capacity of an organization and in no way represents a judgment on the crew or captain. Captain Rogers and the crew of the USS VINCENNES faced one of the most intense, complicated, and uncertain scenarios this author has ever encountered. They made mistakes, but their mistakes were very human which makes this case study particularly relevant to the area of organizational resiliency.

The situation in the Persian Gulf in 1988 was tense after eight years of the Iran-Iraq war. Iraqi Air Forces escalated the conflict in 1987 by conducting air strikes on Iranian shipping and oil facilities. In 1987, following the accidental Iraqi attack on the USS STARK killing dozens of US servicemen as well as Iranian attacks on shipping vessels, the US began escort services for Kuwaiti reflagged tankers. Iran perceived the escorting of merchant vessels as an attack on their interest and began a series of anti-shipping operations using mines, swarm attacks, surface to

ship missiles, and air to surface attacks which resulted in the USS SAMUEL ROBERTS striking a mine on 14 April 1988. The US responded to the Iranian mining operations with OPERATION Praying Mantis leading to a series of intense attacks by air and sea between the two nations. The US attacked several oil mining platforms within Iranian territorial waters and in the process engaged several Iranian fighter aircraft. Iran, meanwhile, fired several of their potent Silkworm surface to surface missiles against the US Surface Action Group. These events took place in the vicinity of the 3 July 1988 shoot down.[2]

The USS VINCENNES deployed short notice to the Persian Gulf on 25 April 1988. Having been ordered to deploy in the middle of Fleet Exercise (FLEETEX) 88-2, the USS VINCENNES reported a high state of readiness and training. Importantly, however, all their training in the exercises involved responding directly to sea and air threats like those seen in early 1988 with little focus on perhaps the most dangerous situation, differentiating between hostile and unknown air entities in the middle of a sea engagement. Prior to entering the Gulf in late May, the USS VINCENNES received theater specific intelligence updates, commander's guidance, Rules of Engagement (ROE) training, and performed a series of training exercises in the Gulf of Oman. Throughout June, the Iraqi Air Force had stepped up attacks on Iranian oil assets and the Iranians had responded aggressively by increasing the presence and use of F-14 fighter aircraft out of the dual civilian and military use Bandar Abbas International Airport. Heading into 3 July, higher headquarters updated the USS VINCENNES of Iranian aggression including a recent small swarm attack against a Danish ship to which the USS MONTGOMERY responded with warning shots.[3]

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[2] Department Of Defense, Washington DC, "Formal Investigation into the Circumstances Surrounding the Downing of Iran Air Flight 655 on 3 July 1988:" (Fort Belvoir, VA: Defense Technical Information Center, August 18, 1988), https://doi.org/10.21236/ADA203577.

[3] Department Of Defense, Washington DC.

Further complicating the operational environment in the Persian Gulf was the simultaneous presence of aggressive Iranian Air Forces operating amid a complex array commercial air routes. These routes covered 50% of the navigable waters. Because of the sheer quantity of commercial traffic, aircraft altitude became an important discriminator in assessing unknown tracks. Most importantly, air tracks originating in Iran were considered unknown, assumed enemy. Notices to Airmen (NOTAMS) describing the ongoing conflict in the area, high transit altitudes, and warning calls on international frequencies were standard operating procedures to mitigate air threats. These procedures were useful against transiting aircraft but did little for commercial aircraft originating within Iran near the straits of Hormuz such as those coming from Bandar Abbas International Airport. While commercial and military aircraft both used the commercial airways, military aircraft normally emitted Mode I, II, and III signals, or squawks, in their Identification Friend or Foe (IFF) system. Additionally, commercial aircraft largely transited the 20-mile-wide airways directly on centerline and squawked only Mode III IFF. Finally, Iranian Air Flight 655 was a biweekly flight known to the crew of the USS VINCENNES. Furthermore, the commander of the Combined Joint Task Force Mid East (CJTFME) and the USS VINCENNES talked regularly about the challenges of the air environment. Against the backdrop of these contextual factors, the following summary describes events on 3 July 1988.[4]

The surface engagement began with three US Navy ships, the USS VINCENNES, MONTGOMERY, and SIDES, operating in proximity on the morning of 3 July. At 0330Z, the USS MONTGOMERY noticed several small Iranian boats approaching a Pakistani merchant vessel. Over the next 42 minutes, the USS MONTGOMERY and VINCENNES moved north to investigate the small boats. After being ordered to return south, at

[4] Department Of Defense, Washington DC.

0412Z the USS VINCENNES launched a helicopter scouting mission which came under attack by the previous small boats at 0615Z. At this time, the USS VINCENNES sounded general quarters and moved north towards the boats. Over the next 28 minutes, higher headquarters ordered Captain Rogers to take tactical control of USS MONTGOMERY. During this period, the USS VINCENNES observed the Iranian boats approaching within 4 nautical miles. At 0643Z, the CJTFME authorized the USS VINCENNES to engage the Iranian boats. Along with the USS MONTGOMERY, the USS VINCENNES began an intense surface battle involving a high degree of maneuvers. These maneuvers include full rudder turns at 30 knots causing considerable strains on task performance and environmental conditions aboard the ship. During this period, the USS VINCENNES entered Iranian territorial waters without awareness.[5]

At 0650Z, the USS VINCENNES experienced a significant gun malfunction on one of their main two defensive guns. At 0651Z, CJTFME ordered the USS VINCENNES to assume additional control of the USS SIDES which meant that Captain Rogers was now responsible for the defense of three US ships. For the next 12 minutes until 0703Z, the USS VINCENNES engages in a series of highly discombobulating maneuvers to keep their remaining gun aimed at the Iranian boats. This violent maneuvering created conditions where loose items and publications were flying around inside of the ship. The air engagement of Iran Air Flight 655 took place in the seven minutes between 0647Z and 0654Z which coincides with the most dangerous, chaotic, and maneuvering portions of the sea battle.[6]

The following details of the air engagement are taken directly from the investigation report summary. The report provides a more in-depth discussion of the conflicting reports on altitude, aircraft identification,

[5] Department Of Defense, Washington DC.
[6] Department Of Defense, Washington DC.

human factor mistakes, and overall stress on the crew which while interesting, are not necessary for this paper.[7]

- 0647Z - Iran Air Flight 655 was detected by the USS VINCENNES AN/SPY-lA radar bearing 025 degrees, 47 nautical miles, at 900 feet and seconds later was assigned Track Number (TN) 4131.

- 0648Z - USS SIDES detected Iran Air Flight 655, bearing approximately 355 degrees, range approximately 32 miles at 1500 feet altitude. The aircraft continued to close on USS VINCENNES with a constant bearing, decreasing range.

- 0649Z - USS VINCENNES issued warnings on Military Air Distress (MAD) frequencies.

- 0650Z – USS VINCENNES began warnings on International Air Distress (IAD) frequencies to TN 4131 located 025 degrees, 40 nautical miles from their position. Several USS VINCENNES Combat Information Center (CIC) personnel heard, on internal voice circuits, a report of F-14 activity which they believed originated from Ship's Signal Exploitation Space (SSES). A momentary Mode II-1100 IFF indication was detected which was correlated with an Iranian F-14. This was reported throughout CIC over internal CIC voice circuits. Continuous MAD and IAD warnings were ordered at 30 nautical miles (5 total warnings on MAD and 4 total warnings on IAD. USS VINCENNES continued the surface engagement and at this point, experienced the previously mentioned main gun malfunction. To unmask the other gun mount, full rudder (at 30 knots) was applied. This added to the increasing tension in CIC.

- 0651Z - As TN 4131 closed to 28 nautical miles, USS VINCENNES informed Combined Joint Task Force Middle East (CJTFME) via the Middle East Force execution net that she had a closing Iranian F-14 which she intended to engage at 20 nautical miles unless it turned away. USS VINCENNES requested concurrence. CJTFME concurred but told USS VINCENNES to warn the aircraft before firing. Warnings continued, but no

[7] Department Of Defense, Washington DC.

response from TN 4131 was received, nor did it turn away.

- 0652Z - Warnings continued over both IAD and MAD with no response. Although TN 4131 reached the 20 nautical miles point, Captain Rogers decided not to engage. The order was given to illuminate the contact with fire control radar. There were no electronic support measures indicators present. TN 4131 was ascending through 10,000 feet.

- 0653Z - At 15-16 nautical miles, the last warning over IAD was given by USS SIDES to the aircraft bearing 204 degrees to USS VINCENNES, range 15.5 miles. At this point, Captain Rogers was passed inaccurate information indicating the aircraft was descending in altitude. During the last 30 seconds of this minute, Captain Rogers made his decision to engage TN 4131.

- 0654Z - The CO turned the firing key. At approximately 06:54:22, two SM-2 Block II missiles left the rails. Twenty-one seconds later, they intercepted Iran Air Flight 655 at a range of 8 nautical miles from USS VINCENNES at an altitude of 13,500 feet.

The report indicates a series of factors ultimately determined the course of the crisis. First, multiple events including Iranian surface attacks against the USS VINCENNES and its helicopter created a perception of a coordinated attack. These events, coupled with the revised ROE issued in June allowing commanders increased measures to defend themselves, masked the uncertainty in the situation, Second, the aircraft was mistakenly identified as an F-14 based on an inaccurate assessment of a Mode II squawk. This Mode II information likely originated from an incorrectly placed IFF range gate which remained on top of Bandar Abbas airfield despite the track progressing towards the USS VINCENNES. In other words, the Mode II information came from some military aircraft at Bandar Abbas. Multiple crew reported seeing Mode II information although all post-mission recording tapes of the USS

VINCENNES demonstrated that TN 4131 never squawked anything other than Mode III. Crewmembers in the USS SIDES were aware of this information and questioned internally the identification of TN 4131 as a hostile F-14. These crewmembers assessed the track as commercial traffic.[8]

Third, range and altitude information passed to Captain Rodgers was accurate until 0653:45Z. After this point, the Tactical Information Coordinator (TIC) reported decreasing altitude values potentially confusing decreasing range with decreasing altitude. Fourth, the time pressure experienced by Captain Rogers did not allow him to personally confirm all the data being presented to him. The goal of this paper is to articulate how higher organizational resilience may have altered the pathway to crisis.[9]

What follows is not a critique of the crew's actions. Rather, this paper uses this case study as the backdrop to apply the principles of organizational resiliency. It is important to note that, in doing so, it is impossible to isolate organizational factors to merely the USS VINCENNES or isolate any one disruption in the scenario. The USS VINCENNES was a distinct organization and yet it was part of a larger three-ship adhoc organization, as well as the broader CJFTME and US Navy organizations. Additionally, multiple disruptions in this crisis could be considered novel and/or routine depending on the level of analysis and the actors involved. For instance, a sea threat, an air threat, a malfunctioning gun, and inaccurate communication transmissions may be routine when occurring in isolation. Coupled together, however, these disruptions present novel challenges to the crew. A malfunctioning gun in the middle of a sea battle while facing a perceived air threat is anything but routine. Therefore, the appropriate framework for thinking about organizational resiliency and the crisis cycle involves overlapping

[8] Department Of Defense, Washington DC.
[9] Department Of Defense, Washington DC.

and interacting dynamics as Figure 11 shows below.

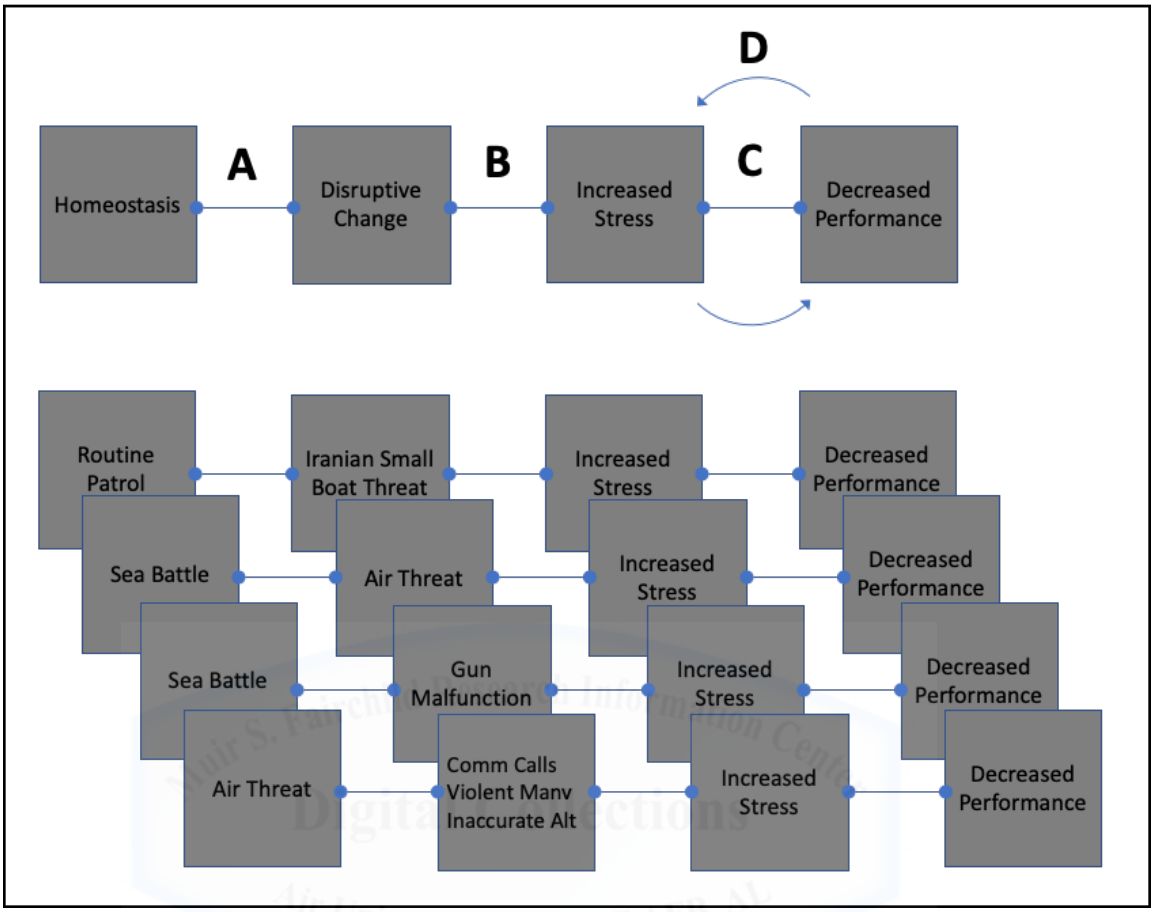

Figure 11: USS VINCENNES' Dynamic Crisis Cycle
Source: Author's Original Work

In this model, stress increases and performance decreases across a spectrum of interacting disruptive changes. Chronologically, the Iranian small boat threat is a disruptive change from the USS VINCENNES early morning patrol. Once the sea battle is considered a new level of homeostasis that the crew was certainly trained to handle, the emerging air threat, the gun malfunction, and the myriad of other factors (excessive communication calls, violent maneuvering, and inaccurate altitude readouts) all worked together dynamically to increase stress and decrease performance. The framework offered by this paper argues that greater organizational resiliency may serve as off ramps at any of the four resiliency points (A,B,C,D) and could have helped the USS VINCENNES

navigate around or through the disruptive changes they faced in 1988.

Section 2: The Influence of Organizational Resiliency

This section begins by asking an important question about where the USS VINCENNES was most brittle, or fragile, in terms of their operating envelope. It approaches this question through the most dangerous course of action (MDCOA) framework.[10] Next, it considers what actions the USS VINCENNES, the CJTFME, and US Navy could have taken leading up to the shoot down in the areas of preparedness, responsiveness, adaptability, and learning. Specifically, what could these organizations have done to increase their adaptive capacity to avoid, if possible, and reduce, if necessary, the negative interactions of stress and performance in the face of the disruptive change brought about by the perceived air threat. Finally, this section discusses how those four organizational drivers may have altered the pathway to crisis. While a higher level of organizational resiliency may not have eliminated the complexity and uncertainty of that day, it may have enabled enough off ramps to minimize the negative effect of stress on performance in both routine and novel tasks that contributed to the tragic shoot down.

When considering the following analysis, it is important to remember the resiliency of an organization is developed prior to the appearance of crisis-causing disruptive change. Therefore, most of the following discussion will focus on how the USS VINCENNES, the CFJTME, and the US Navy could have increased their organizational resiliency, or adaptive capacity, prior to the morning of 3 July 1988. Furthermore, there is no evidence that the USS VINCENNES lacked any of the three cultural traits which serve as a foundation for organizational resiliency. According to the report, the USS VINCENNES had a tight-knit crew led by a competent commanding officer. Furthermore, there is no evidence in the report that trust, openness, or lack of identity were

[10] Joint Chiefs of Staff, "Joint Publication 5-0, Joint Planning," 2017, https://www.jcs.mil/Portals/36/Documents/Doctrine/pubs/jp5_0_20171606.pdf.

factors affecting the crew. Therefore, the primary focus of this section will be on enhancing their drivers of resiliency (Preparedness, Responsiveness, Adaptability, Learning-Organization).

Brittleness and the Most Dangerous Course Of Action

Increasing the USS VINCENNES' organizational resiliency begins with asking the question: "Where in their operational envelope were they most brittle, or fragile?" In military parlance, this question, and its possible answers, takes the form of course of action (COA) development. In particular, the most dangerous course of action (MDCOA) generally reveals brittle, or fragile, areas within an organization's operating envelope. The report highlights two ways in which the organizations involved in the 3 July 1988 shoot down inadequately approached this question. First, most of the air training prior to July 3rd focused on an attack by a traditional fighter during a surface battle, the exact scenario the USS VINCENNES misperceived that morning. There is no data in either the DOD or CENTCOM report indicating any substantial training towards what became the actual MDCOA.

Second, the operational and tactical resources and procedures at Captain Rogers' disposal were impotent to handle the perceived air threat. Employing lethal force under self-defense usually involves high degrees of uncertainty and very fluid situations. Self-Defense ROE exist precisely to address situations not covered by other standing ROE. Yet, the very procedures in place to handle such a situation had little chance of preventing an accidental shoot down. In other words, the procedures in place made it very natural for the USS VINCENNES to walk down the path of identifying TN 4131 as hostile and then engaging in self-defense.

In preparing for future operations, military organizations often rely on anticipating the enemy's most likely course of action (MLCOA) and the most dangerous course of action (MDCOA). Typically, leaders optimize training for both courses of action (COA) against a set of finite resources. MLCOAs represent challenges and problems a given organization is

generally equipped to handle. Leaders generally seek to be very fluent and capable at handling MLCOAs by focusing training towards these scenarios. MDCOAs, on the other hand, are often COAs that either present overwhelming force or a high degree of uncertainty to the friendly force. MDCOA are "most dangerous" because an organization may struggle to handle them.

By nature, MDCOAs stretch the capacity of an organization, sometimes even to a breaking point. In other words, MDCOAs often push organizations towards the region of their operating envelope where they are most brittle, thus presenting the most difficult adaptive challenge to the organization. In fact, part of identifying an adversary's MDCOA is to assess whether the friendly force is even resourced appropriately and capable of handling such a scenario. The process of building COAs is analogous to looking at a dynamic fitness landscape, anticipating what disruptive changes may suddenly appear, and then assessing whether an adaptive capacity exists to handle these changes. In the 3 July 1988 tragedy, the formal investigation report makes it clear that the USS VINCENNES, as well as the entire CJTFME, were focused primarily on the scenario they mistakenly perceived on 3 July 1988: an air attack by an Iranian F-14 in the middle of a surface engagement. In other words, there was little awareness and focus on the area where the USS VINCENNES, and indeed the entire task force, was most brittle: correctly confirming an air track originating from a dual use airfield was, in fact, a hostile threat.

The formal investigation indicates the primary focus of the USS VINCENNES' training leading up to the 3 July 1988 was on fast boat attacks, Silkworm missile attacks, and air attacks by Iranian fighter aircraft. Furthermore, the theater specific training and intelligence updates provided to the USS VINCENNES did not adequately address the uncertainty and difficulty of handling civilian air traffic originating in Iran. Finally, no evidence from the pre-crisis exercise out briefs or the

post-crisis interviews suggests that the USS VINCENNES had enough procedures or resources in place for handling the exact situation she encountered on 3 July 1988 with any reasonable chance of success. For example, the report notes that within current procedures, unless visual identification (VID) assessed an approaching aircraft as a non-threat, it was considered a threat. There was no VID capability available to Captain Rogers that morning. Taken together, these three broad assessments indicate the USS VINCENNES likely did not develop an accurate MDCOA given all the contextual factors surrounding the Persian Gulf in 1988. Furthermore, given the resources, training, and procedures available to Captain Rogers that morning, the USS VINCENNES found itself in an area of brittleness once the unidentified air threat emerged.[11]

The report offers key insights into the training conducted by the USS VINCENNES in the months and days leading up to the fateful shoot down. The scope of this training reinforces the notion that identifying and mitigating unknown air tracks out of Iran was an area of brittleness for the task force. In February 1988, the USS VINCENNES participated in Middle East FLEETEX 88-1 focusing on Silkworm missile attacks, terrorist aircraft attacks, and terrorist boat attacks.[12] There is no mention of the training including distinguishing between a terrorist aircraft attack and a commercial aircraft flight profile. In April 1988, the USS VINCENNES partially participated in FLEETEX 88-2 focusing on war at sea strike exercises, Silkworm attacks, fast boat attacks, and ROE training.[13]

In May 1988, a War at Sea Exercise (WASEX) included surface engagements, attacking aircraft, fast boat attacks, and Silkworm missile

[11] Department Of Defense Washington DC.
[12] Department Of Defense Washington DC, CENTCOM Report 18.
[13] Department Of Defense, Washington DC, 18.

attacks.[14] Of note, during this exercise, the USS VINCENNES had to distinguish between attacking aircraft and other commercial traffic but there is no indication they trained specifically against commercial aircraft executing similar profiles to attack aircraft. This exercise had attacking military aircraft with civilian aircraft in the radar background. Furthermore, only IFF Mode IV was used to identify threats. Once in theater, the USS VINCENNES received theater indoctrination training which did not include significant discussion of commercial air traffic.[15]

These training exercises give pertinent insight into the perceived MDCOA and MLCOA in the Persian Gulf. For instance, fast boat attacks and Silkworm missile attacks were likely considered part of a MLCOA since they were part of every exercise. Attacking military aircraft were part of some of the exercises but there is no indication in either the DOD or CENTCOM portion of the report that any substantial focus was given to the tremendously difficult problem of identify whether an aircraft on a perceived attack profile was a commercial and military aircraft. This assessment is further informed by five theater standing procedures for handling potential air threats which were impotent to prevent a fratricide event.[16]

The first procedure was to issue voice warnings to suspect aircraft on preset frequencies. However, flights originating out of Iran near the Hormuz Straits would likely be in intense air traffic control (ATC) communications when receiving the voice warning. This radio congestion meant that there would be little chance of Iranian Air flights receiving the transmission or the US Navy ships hearing an acknowledgement. Second, these verbal warnings did not clearly identify the specific aircraft being hailed. Third, CJTFME did not begin distributing reoccurring

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[14] Department Of Defense, Washington DC, 18.
[15] Department Of Defense, Washington DC, 18.
[16] Department Of Defense Washington DC, "Formal Investigation into the Circumstances Surrounding the Downing of Iran Air Flight 655 on 3 July 1988."

commercial flight information to their ships until 28 June 1988. Therefore, despite months of heightened tensions in the Gulf, there was no established process for tracking the roughly 1000 weekly scheduled flights throughout the Persian Gulf.[17]

Fourth, altitude and IFF squawks were the primary data points used to identify potential hostile aircraft. Aircraft transitioning above twenty-five thousand feet with just a Mode III IFF squawk were assessed to be commercial traffic. However, the very aircraft posing the biggest threat to the task force - those originating within Iran - would likely never meet that altitude threshold as they climbed out of coastal Iranian airports. Fifth, all aircraft originating in Iran were initially coded as unknown, assumed enemy.[18] The report notes this procedure potentially made it easier for crewmembers to drift towards a positive identified hostile declaration in the middle of a surface battle, part of a phenomenon known as a self-fulfilling prophecy. Taken all together, the lack of focus on commercial traffic during exercises, the inadequate information passed at theater indoctrination, and the impotent procedures for managing a complex air environment indicate a lack of preparedness, responsiveness, and adaptability for handling the exact problem posed to the task force on 3 July 1988. Put another way, a higher degree of organizational resiliency may have anticipated a more accurate MDCOA involving the very scenario the ship faced with Iran Air Flight 655.[19]

Given the overwhelming focus on attacks from military aircraft and the lack of adequate operational or tactical procedures to handle a situation like the one occurring on 3 July 1988, what could have been done differently in the days and months leading up to the shoot down?

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[17] Department Of Defense, Washington DC.
[18] Department Of Defense Washington Dc, 15–18.
[19] Department Of Defense Washington Dc, "Formal Investigation into the Circumstances Surrounding the Downing of Iran Air Flight 655 on 3 July 1988."

The following considerations are by no means exhaustive but serve as examples of adaptive thinking and processes which could have altered the course of events.

Preparations and Alternative Measures Strengthening Resiliency

A more resilient organization would have considered an integrated surface battle and the problem of distinguishing the identification of an air track on a commercial route as a more accurate MDCOA. In other words, the principle challenge in the air domain was identification of a threat, not defending against an attack. Avoiding an accidental shoot down of a commercial airline in the dense Gulf environment was the key air challenge facing the Navy task force. Put yet another way, resolving uncertainty was the key problem should an unknown air contact track towards the ship during a surface battle. Instead, most of the ships' training and exercises focused on defending air attack from a known Iranian fighter, something the USS VINCENNES was clearly adequately prepared for as demonstrated in the 3 July shoot down. This misperception of the MDCOA is an easy mistake to make in training and exercises.

Increasing the volume of an event (more surface and air attacks) does not necessarily create the most dangerous course of action. Rather, larger uncertainty and time compression is often what makes an event so dangerous, especially when dealing with complex systems. In the case of the USS VINCENNES, the uncertainty presented by an airline tracking towards the ship in the middle of a perceived coordinated attack was the most arduous problem to solve. A better sense of the likelihood of misperceptions in this scenario may have changed the way the USS VINCENNES and the entire CJTFME developed resources and capacities to handle such a scenario. The four considerations below are compiled from a few of the recommendations contained in the investigation report, as well as the application of the drivers of organizational resiliency. Taken together, these steps could have increased the preparedness,

responsiveness, adaptability, and learning of the organizations involved in the shoot down.

Improving adaptive capacity by deepening information networks

First, the CJFTME could have made a better effort to coordinate with Embassies, International Civil Aviation Organization (ICAO), and Iran on the significant danger posed to commercial air traffic in the Gulf. This may have resulted in Iranian aircraft monitoring frequencies better and climbing to a predetermined altitude before proceeding over the Gulf. Second, the CJFTME could have incorporated better guidance in their indoctrination brief regarding commercial air traffic and formalized the distribution of regular commercial air flight. routes and times originating from within Iran.[20]

Identifying brittleness in MDCOA development and training

Third, training exercises could have focused squarely on dealing with a potentially unconfirmed Iranian commercial aircraft approaching US Navy ships amid a surface engagement. This exact scenario during training may have revealed to Navy decision-makers the intense time pressure and enormous uncertainty they would face should such a situation present itself on deployment. A training scenario simulating an event like the one occurring on 3 July 1988 may have revealed their organization's brittleness, or fragility, in the realm of identifying and managing commercial airline traffic during a surface engagement.

Developing structural redundancy and cross-level collaboration

Knowing this brittleness, Navy decision-makers may have developed at least two capacities to increase the responsiveness of the task force amid such a disruptive change.[21] First, CJTFME may have invested in a real-time data link for their headquarters to assist subordinate ships in identifying commercial air traffic. Remember, the Link 11 datalink showed only a Mode III reply for Iranian Air Flight 655

[20] Department Of Defense, Washington DC.
[21] Department Of Defense, Washington DC.

throughout the engagement, something easily caught by an observing and detached higher headquarter. However, the CJFTME did not have access to the link picture and could not back up the USS VINCENNES regarding the inaccurate Mode II report. Second, certain individuals on board the USS SIDES expressed significant doubt of TN 4131's classification as an F-14 instead of a commercial airliner. Cross-ship verification and resolution of identification issues may have been an adequate responsive capacity to prevent TN 4131's persistent hostile ID-tag. There is no evidence the USS VINCENNES had this process or capacity in the middle of the crisis.

Amplifying signal strength in the presence of high-risk noise

Finally, the USS VINCENNES could have significantly identified radar procedural challenges for providing air surveillance over the dual-use Bandar Abbas airbase. In late June, intelligence assessments indicated that F-14 aircraft were repositioned to Bandar Abbas airbase presenting a very proximate air threat to Navy ships in the Straits. Properly understanding the uncertainty presented by a close dual-use airbase may have encouraged supervisors on the USS VINCENNES to identify the potentially fatal error that could emerge if track management on Link 11 was not performed adequately. According to the report, the erroneous Mode II report, which ultimately led to the tagging of Iran Air Flight 655 as a hostile F-14, likely came from keeping the IFF range gate on Bandar Abbas airfield despite the track moving on the screen towards the USS VINCENNES.[22] It was likely a Mode II reply of an Iranian military on the ground at Bandar Abbas that the operator associated with TN 4131.[23]

A greater degree of organizational resiliency could have offered the best opportunity to anticipate and outmaneuver the disruptive change

[22] Department Of Defense, Washington DC, 4.

[23] Department Of Defense Washington DC, "Formal Investigation into the Circumstances Surrounding the Downing of Iran Air Flight 655 on 3 July 1988."

manifested by the air threat. The USS VINCENNES may not have been able to avoid uncertainty, stress, or degraded performance due to the appearance of Iran Air Flight 655 in the middle of an intense surface battle. However, greater organizational resiliency could have taken the form of organizational processes that enabled better tracking and distribution of routine commercial air traffic. It could have taken the form of procedures that confirmed and validated the identification label of Iran Air Flight 655 with other ships in the task force prior to shooting. It could have involved anticipating, and therefore preparing, for the IFF mismatch due to range gate error that could occur once Bandar Abbas became an offensive dual-use airfield. The following discussion illustrates how implementing any of four previous considerations in the weeks and months leading up to the shoot down may have increased organizational resiliency and provided off ramps during the crisis cycle.

Organizing for Resiliency

Consider the basic framework as presented in Chapter One as it applies to two interacting disruptive changes: the presence of an air threat and the continuous disruption in routine tasks (communication calls, violent maneuvers, and inaccurate reported altitude of Iran Flight 655) (see Figure 12). While these two disruptive changes are only two of multiple changes facing the task force, they serve to illustrate the concepts developed in this paper. Specifically, the combined aspects of an unidentified air track on commercial routing amid a dynamic sea battle with severe ship malfunctions created a novel task for the decision-makers in the task force. For the crewmembers on the radar and weapons stations handling the air domain, the air threat was a routine task. The difference in task type largely depends on different levels of analysis. For the decision-makers, the air threat (disruptive change) was a novel task considering ongoing gun malfunctions, the surface battle, and controlling the new adhoc three-ship task force. On the other hand, the radar and weapons crewmembers experienced a

series of interruptions (disruptive changes) in the routine tasks of detecting, tracking, identifying, and targeting a perceived air threat.

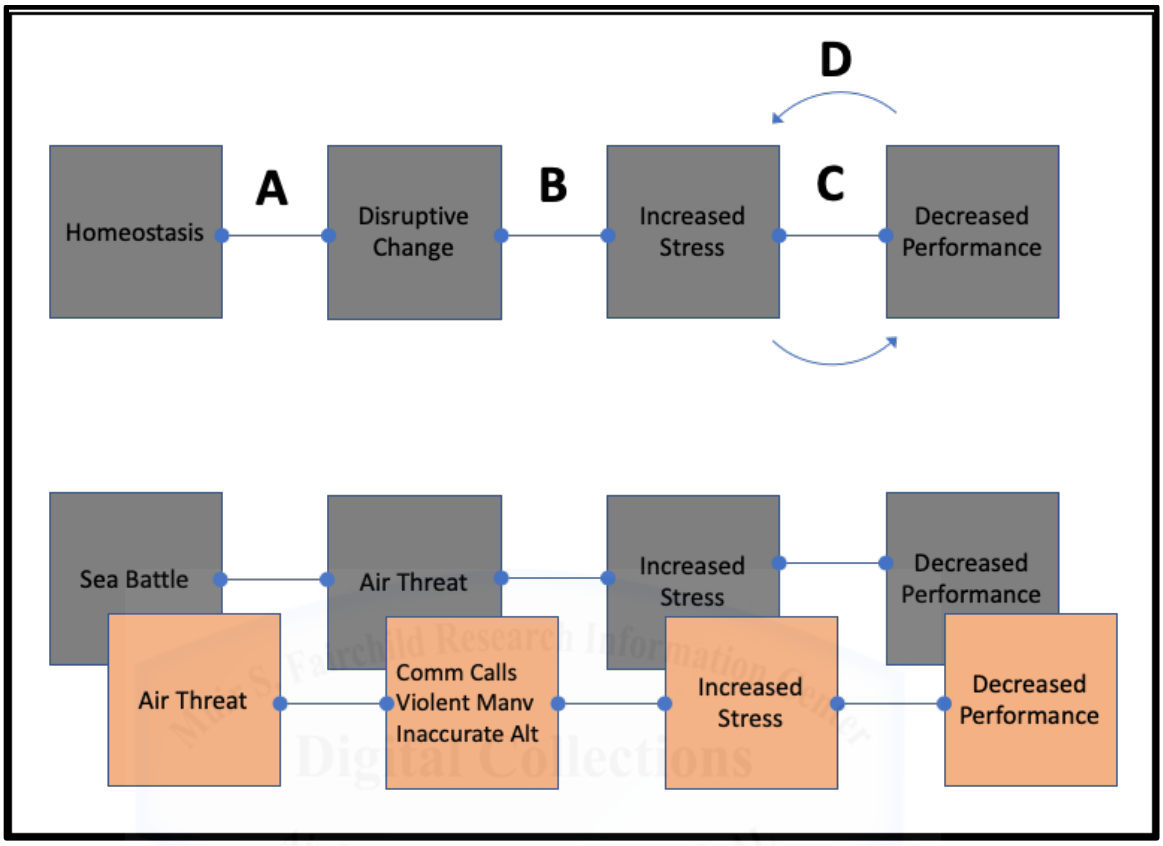

Figure 12: USS VINCENNES and Two Interacting Disruptive Changes
Source: Author's Original Work

Resiliency Point A

The concepts of organizational resiliency described in this paper suggests that high degrees of organizational resiliency could have influenced the navy task force at Point A. Acting here, the drivers of organizational resiliency could have helped the organizations involved in the 1988 shoot down, sense impending disruptive changes and then maneuver their organization around these changes effectively avoiding the crisis in the first place. This influence acts in a way depicted in Figure 13.

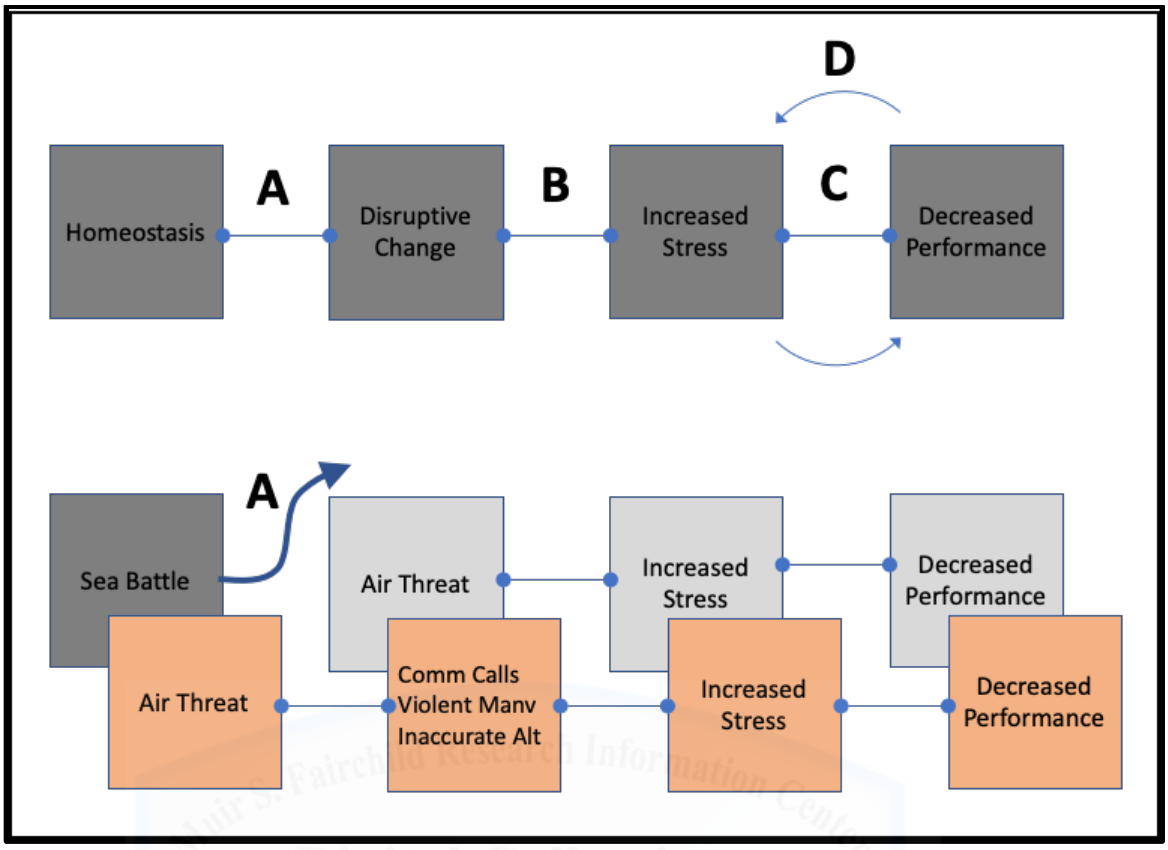

Figure 13: Resiliency Off Ramp: Point A
Source: Author's Original Work

Developing a better MDCOA, coordinating at the Embassy and ICAO level on commercial flight routes, exercising scenarios involving a similar situation to the 3 July 1988 shoot down, and incorporating operational and tactical procedures designed to identify aircraft out of dual use airfields could have increased the organizational resiliency to a level sufficient enough to avoid the disruptive change all together. These steps would have increased preparedness, responsiveness, adaptability, and learning across the organization.

With a different level of organizational resiliency, Iran Air Flight 655 would have still taken off from Bandar Abbas airfield on 3 July 1988, but the USS VINCENNES may have quickly been able to dismiss the air track as a commercial airline on route. Imagine if the task force had a resilient process for handling dual-use airfields close to the Straits

of Hormuz. Once the surface battle commences, the entire task force is anticipating the emergence of the MDCOA. At the start of the surface battle, the crewmembers responsible for air defense could have been poised to compare any airborne tracks out of Bandar Abbas with daily planned commercial flights and their Mode III squawks. Consequently, as soon as TN 4131 is airborne, all air defense crewmembers recognize the principle challenge to be the proper identification of Flight 655, not merely the defense of the ship. Radar operators would have been aware of the extreme importance of adjusting IFF range gates as TN 4131 moved closer to the task force so as avoid a bleed over Mode II reply from a military aircraft on the ground. Other crewmembers could have crosschecked TN 4131 Mode III reply with known Iranian commercial flight routes and ATC-assigned Mode III values.

Moreover, had the MDCOA included misperceiving a commercial flight with a hostile military aircraft, Captain Rogers' leadership team would have quickly exercised cross-ship verification of aircraft identification learning that all other ships showed Flight 655 with increasing altitude and only a Mode III reply. At the very least, this process would have given Captain Rogers' cause to question the misreported F-14 hostile identification. Meanwhile, knowing the gravity of a misperception at this stage in the scenario, the individuals reporting an inaccurate Mode II and descending altitude could have had a robust sensor crosscheck and supervisory backup assessment of these important parameters. Since a single fatal decision by the Identification Supervisor (IDS) created the hostile F-14 identification in the ship's system, having multiple assessments at this critical point may have been enough adaptive capacity to avoid the crisis.[24]

Finally, the CJTFME equipped with a Link 11 repeater could have questioned the hostile identification of TN 4131 once Captain Rogers

[24] Department Of Defense, Washington DC, 2.

indicated his intent to higher headquarters to engage the threat. The hypothetical alternative scenario outlined above would still have been a disruptive change at some level. However, it is possible that a higher degree of preparedness, responsiveness, adaptability, and learning may have provided an off ramp in the crisis prior to the perception that TN 4131 was an air threat.

Recall from Chapter Three that preparedness includes "resources (building buffers and alternative resources), functions (crisis planning and setting procedures) and training all people and leaders."[25] Responsiveness involves a timely and adaptive response through the activation of informal networks, ideas, and processes.[26] In the case of the USS VINCENNES, the buffer and activation of alternative resources, networks, ideas, and processes may have included using other ships in the task force, higher headquarters, VID capabilities, and relationships with external agencies like Embassies and ICAO. These resources could also have contributed to higher degrees of adaptability.

Adaptability is about growing a dynamic capacity to maintain resources that are flexible, storable, convertible, and malleable enough to capitalize on unexpected changes.[27] However, for these alternative resources to be available, they must be developed ahead of time. The development of these resources requires a solid assessment of problems and risk which is at the heart of developing a learning organization. Learning processes involve absorbing internal and external knowledge, making accurate assessments of risk and decision-space, and having a willingness and process to learn from experience.[28] In the case of the USS VINCENNES, this assessment would have fed into crisis planning and the procedural functions of preparedness including the MDCOA

[25] Koronis and Ponis, "Better than Before."
[26] Koronis and Ponis.
[27] Koronis and Ponis.
[28] Koronis and Ponis.

development, operational-level procedures for handling commercial traffic, and intra-ship battle plans. In the case of the CJTFME, training and exercises could have stress-tested the degree to which members at all levels of the organization understood contingency plans, specifically in the case of the MDCOA.

Therefore, the USS VINCENNES, and the entire CJTFME, could have anticipated and sensed the potential disruptive changes that appeared on the morning of 3 July 1988. Greater organizational resiliency may have developed a more robust enemy most dangerous course of action (MDCOA), informed training and exercise plans, and informed leadership of critical tipping points in operations should the most dangerous course of action materialize. This, in turn, could have generated enough adaptive capacity to completely avoid misperceiving Iran Air Flight 655 as an imminent air threat to the USS VINCENNES.

However, even if the adaptive capacities described existed, the USS VINCENNES and CJTFME may not have been able to completely avoid initially perceiving the appearance of Iran Air Flight 655 as an air threat. Yet, the same efforts at increasing preparedness, responsiveness, adaptability, and learning outlined above could have influenced the crisis cycle at different points. Greater organizational resiliency could have influenced the crisis cycle at point B by reducing the amount of stress experienced by routine operators and decision-makers alike once a potential air threat had been identified.

Resiliency Point B

Recall from Chapter One, that disruptive changes produce stress commensurate with a perceived threat to continued existence or functionality. Therefore, even if the USS VINCENNES misperceived TN 4131 as an air threat, greater organizational resiliency could have limited the amount of stress this threat generated for the crew and provided an off ramp at point B (see Figure 14).

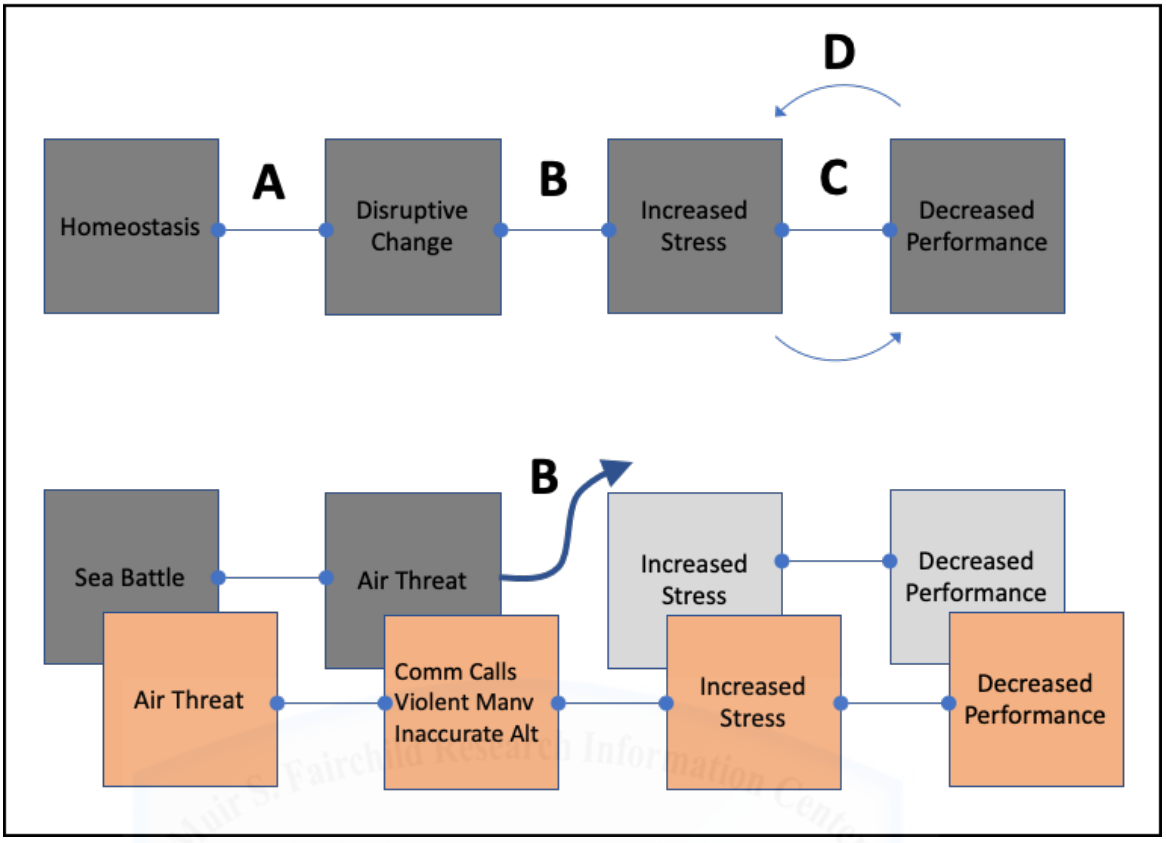

Figure 14: Resiliency Off Ramp: Point B
Source: Author's Original Work

It is true that any disruption from homeostasis will produce a certain amount of stress.[29] However, the presence of stress is not the critical factor. Rather, it is the amount of stress that matters. As articulated in Chapter Two, the principle challenge related to stress and performance is keeping stress below the tipping point for both novel and routine tasks. This goal is achieved to the extent that organizations do not feel threats to their continued functionality. For the USS VINCENNES, reducing the perceived threat from an air track out of Iran could have been accomplished by the development of a more accurate MDCOA, training against this MDCOA, and developing adaptive capacities to handle such a scenario.

[29] Steckler, Kalin, and Reul, *Handbook of Stress and the Brain Part 1*, 25.

Resiliency Point C and D

The effect of stress on performance was a principle factor considered by the DOD investigation. For instance, one recommendation by the CENTCOM and DOD reports directly addressed this challenge. The report recommended the Chief of Naval Operations (CNO) develop a Command, Control, Communication, and Intelligence (C3I) program to evaluate the impact of human stress on operations. "Integral to this program would be the incorporation of measures of human effectiveness into battle simulation techniques to assess the effect of peak overloads and stress on the human players."[30] Organizational resiliency specifically addresses the concept of effectiveness and performance under stress. It does so by providing off ramps in the crisis cycle at resiliency points C and D. (Figure 15/Figure 16).

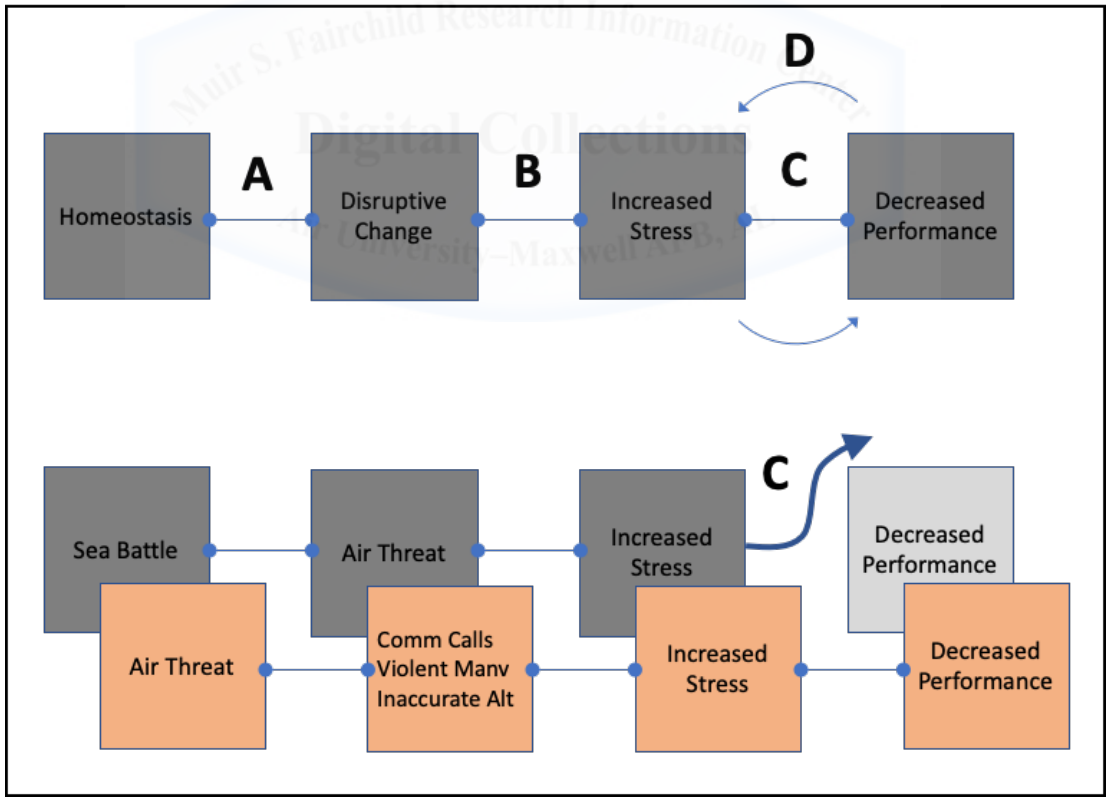

Figure 15: Resiliency Off Ramp: Point C
Source: Author's Original Work

[30] Department Of Defense, Washington DC, "Formal Investigation into the Circumstances Surrounding the Downing of Iran Air Flight 655 on 3 July 1988."

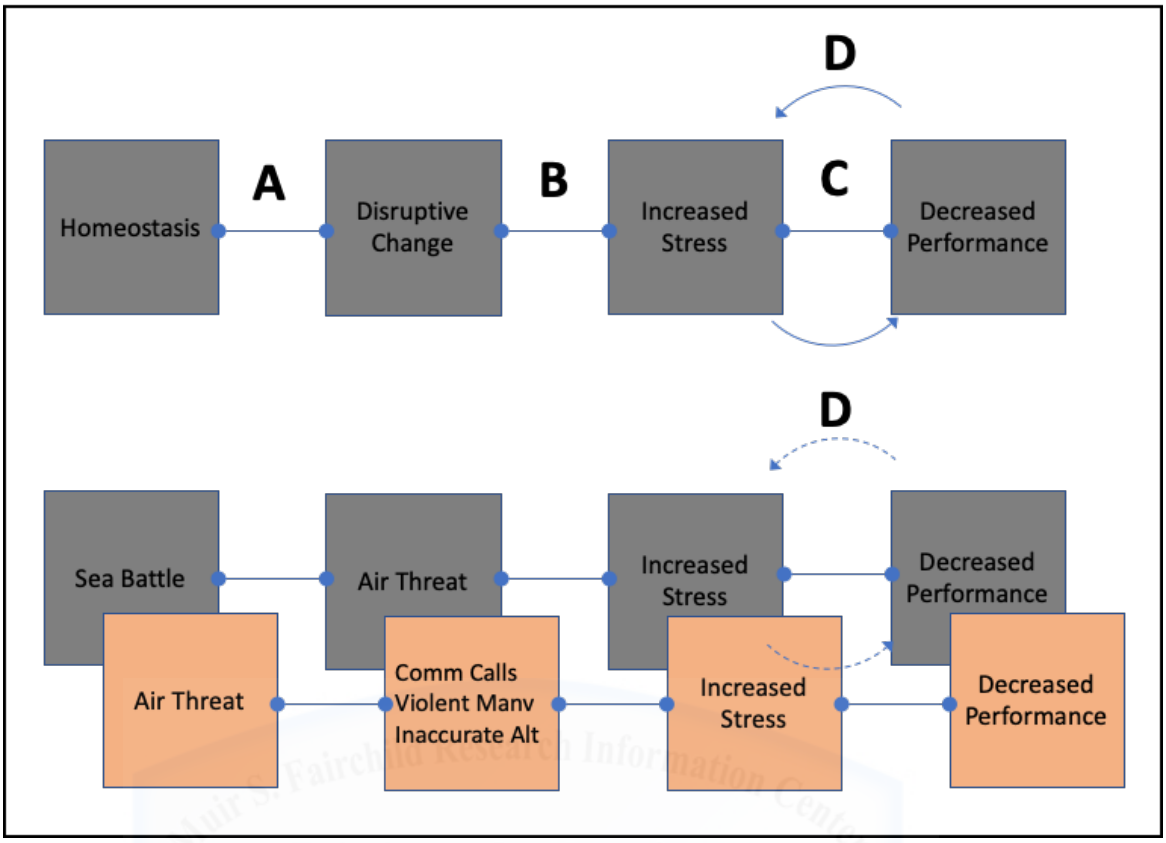

Figure 16: Resiliency Off Ramp: Point D
Source: Author's Original Work

Recall from Chapter Two how stress can negatively affect performance by impairing explicit memory functions for novel tasks and creating quantity-induced crises due to continuous interruptions of routine tasks. Chapter Two also highlighted two different approaches to counter the inverted relationship between stress and performance depending on task type. When facing novel tasks in the presence of high stress, one established practice is the "step back" approach whereby core assumptions are revisited, situations are reframed, and tasks are offloaded to other entities. However, as Chapter Two notes, when facing routine tasks in the presence of continuous interruptions, the "step back" approach actually impairs performance. Instead, adhering strictly to established procedures and employing escape strategies is the best practice. For the USS VINCENNES, greater organizational resiliency may

have created the capacity to correctly employ both practices given the two types of tasks facing the ship's crew.

This paper suggests the perceived air threat posed by Iran Air Flight 655 represented a novel task for Captain Rogers considering he was simultaneously leading a newly formed three-ship task force, engaged in a serious surface engagement in Iranian waters, and handling a severe ship malfunction. Therefore, it would have been best to employ the "step back" approach, granted time was of the essence. This approach would have involved revisiting the assumption that air tracks originating in Iran were assumed enemy, revisiting TN-4131 hostile F-14 declaration, and revisiting the assumption that TN 4131 represented a coordinate air and sea attack.

This approach would have also required him to offload some of the tasks facing the ship. Offloading tasks could have included passing identification issues and defense to the USS SIDES operating 18 nautical miles away, to Italian naval ships operating nearby, or to airborne American F-14s from a nearby carrier strike group. Furthermore, the report notes the Iranian boats never came within 4000 yards, indicating that Captain Rogers could have either retreated or passed of defense of the ship to the nearby USS Montgomery.

Moreover, it could have included personally querying whether any known commercial air traffic was scheduled for takeoff out of Bandar Abbas at that moment. However, for any these actions to have taken place in the short time span available, the adaptive resources, procedures, and processes had to already be in place as mentioned previously. Therefore, the "step back" approach which would have helped resolve uncertainty, could have only worked if the four organizational drivers of resiliency had been more robustly developed prior to 3 July 1988. In other words, it may have provided an off ramp at Point C in the crisis cycle. Instead, what happened was performance decreased as Captain Rogers persisted in handling this dynamic situation by ordering

30 knot violent turns which created chaos across the ship's routine tasks.[31]

The chaos that ensued as the scenario developed created a series of continuous interruptions in the routine tasks performed by the air defense crew members. The report notes the violent maneuvers created flying debris within the ship. Multiple command frequency nets were continuously transmitting information. The Tactical Information Coordinator (TIC) continuously broadcasted the range and altitude of TN 4131on a critical frequency net. These interruptions produced a series of performance degradations including multiple incorrect attempts to perform weapon authorizations out of sequence.

The most egregious performance degradation was when the TIC misread altitude for range thus indicating the aircraft was descending on attack profile. In the last minute before the shoot down, the TIC became hysterical and was yelling inaccurate range and altitude information which he could have confirmed was wrong by referencing his own displays. What he needed to do was strictly adhere to established procedures of a healthy crosscheck regarding altitude, IFF replies, and range data on his display. Furthermore, any number of individuals could have provided backup checks on the pertinent data. These are just two of several actions that would have influenced the crisis cycle at Point D by reducing the dynamic feedback loop occurring on the ship. Instead, cross check procedures broke down, no one adequately backed up the TIC's data reporting, and the captain authorized the engagement believing TN 4131 was on final attack run against the USS VINCENNES.[32]

The USS VINCENNES faced a difficult situation on 3 July 1988. The events unfolding that day on the Gulf and inside their ship are examples of complex adaptive systems at work. A series of disruptive

[31] Department Of Defense, Washington DC, "Formal Investigation into the Circumstances Surrounding the Downing of Iran Air Flight 655 on 3 July 1988."
[32] Department Of Defense, Washington DC.

changes increased stress throughout a host of novel and routine tasks. This stress impacted the performance of these tasks in a dynamic manner, sometime creating new disruptive changes in the process. This chapter suggests the USS VINCENNES and CJTFME could have best succeeded in handling this dynamic situation by developing a greater degree of organizational resiliency in the preceding months beginning by considering brittleness.

Developing a more accurate MDCOA may have revealed the areas of their operating envelope where they were most brittle. Knowing where they were brittle may have incentivized developing adaptive capacities which could anticipate, absorb, and respond to the situation they faced that morning in July 1988. These adaptive capacities could have been built by improving preparedness, responsiveness, adaptability, and learning across the span of organizations involved in the manner suggested throughout the chapter. These four organizational drivers could have provided sufficient off ramps throughout the crisis cycle to reduce the likelihood of the Iran Air Flight 655 shoot down occurring.

For the squadron commander, this case study provides practical insights into notions of brittleness, organizational resiliency, and strategies to handle routine and novel task performance in the presence of high degrees of stress. Chapter Five will offer a brief conclusion of the ideas discussed in this paper, offer some practical insights for squadron commanders who lead socio-technical organizations, and discuss further areas of research on the topic of organizational resiliency.

Chapter 5
Conclusion

This study investigated how organizational resiliency can improve how Air Force squadrons detect and navigate crises. To answer this overarching research question, this study considered a series of subordinate questions regarding the nature of crises, the negative effect crisis-producing stress has on performance of novel and routine tasks, and how organizational resiliency can help mitigate a crisis cycle. This study used a qualitative research methodology by drawing on relevant crisis management, cognitive psychology, and organizational theory literature to create a framework which was applied to a case study involving the mistaken shootdown of Iran Air Flight 655 in 1988. The framework indicates that strong organizational resiliency provides off ramps during a typical crisis cycle that can help minimize the negative effects on performance of novel and routine tasks (see Figure 17).

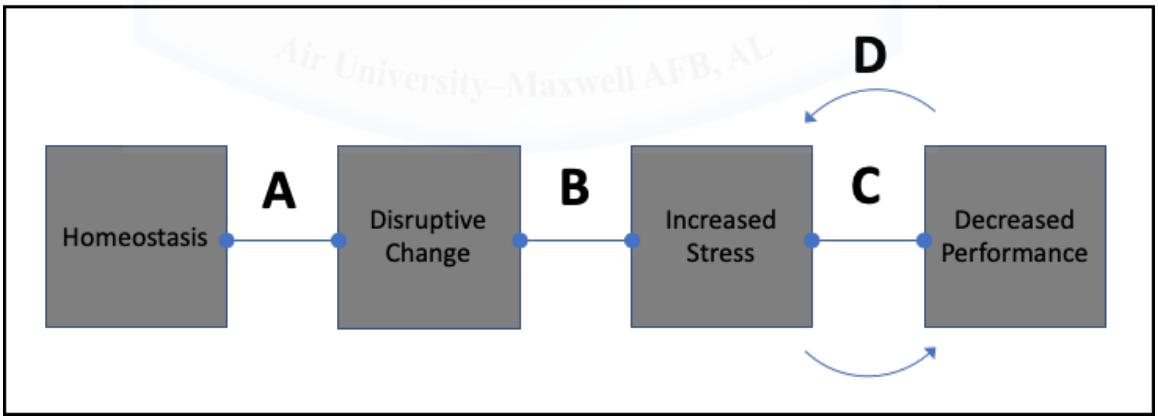

Figure 17: Crisis Cycle Framework
Source: Author's Original Work

Chapter One characterized crises as disruptive changes that stress the adaptive capacity of a given organization by threatening the organization's continued functionality. These disruptive changes are a result of living and operating in a world marked by complex adaptive systems where change is constant. These disruptive changes generate

stress on organizations and affect the performance of novel and routine tasks, especially for complex socio-technical organizations like many Air Force squadrons.

Chapter Two argued that stress initially increases performance of both novel and routine tasks until an inflection point is reached. At that point, stress, due to disruptive change, can negatively affect the performance of novel and routine tasks in two different ways. First, if the disruptive change creates novel tasks in the form of planning, problem-solving, or creative thinking, high levels of stress significantly decrease cognitive performance in these tasks. Moreover, as the crisis plays out in time, past stress compounds the challenges associated with performance of new tasks by lowering the stress required to trigger the performance inflection point in the present. Mitigation strategies include taking a "step back" whereby leaders revisit core assumptions, reframe the situation, recombine existing procedures and routines into alternative responses.

Second, if disruptive changes continuously interrupt routine tasks, stress increases as the organization expands its capacity to resolve these interruptions. Once the organization's resolution capacity is overstressed, a dynamic feedback loop occurs where increased stress results in an exponential decrease in performance of routine tasks. Mitigation strategies in these quantity-induced crises include a strict adherence to established procedures while employing escape strategies to handle the interruptions that still need to be resolved. The negative interactions between disruptive change, stress, and performance in a crisis cycle is what organization resiliency seeks to mitigate.

Chapter Three argued that organizational resiliency is an organization's adaptive capacity to anticipate, absorb, respond to, and capitalize on specific disruptive changes that threaten the functionality or survival of the organization. Strong resiliency is based on trust, a perceived organizational identity, and open culture. Furthermore,

preparedness, responsiveness, adaptability, and learning are four drivers of resiliency that help identify where in its operating envelope an organization is most brittle, and then provide the adaptive capacity to maneuver the organization away from these brittle operating areas.

Furthermore, organizational resiliency influences the pathway through crisis by opening off ramps at four key resiliency points. These resiliency points can help mitigate the negative dynamic interactions between disruptive change, stress, and performance as shown in the case study regarding the mistaken shootdown of Iran Air Flight 655. Ultimately, organizational resiliency is about developing graceful extensibility which is the ability to continue to operate at diminished organizational capacity while maneuvering the organization away from areas of brittleness through resource transference.[1]

The main conclusions of this study are that strong organizational resiliency can help Air Force squadrons detect and navigate crises in at least two different ways. First, strong organizational resiliency helps squadrons detect crises by establishing the cultural traits and organizational drivers that enable all personnel, regardless of rank or position, to sense and communicate impending disruptive changes throughout the organization. In this way, strong organizational resiliency enables an organization to maneuver around potential disruptive changes. Moreover, as the case study demonstrated, both leaders and lower level personnel play a crucial role in crisis detection.

Leaders can establish the cultural traits and organizational drivers that foster strong organizational resiliency prior to the crisis emerging. In other words, they develop the social and physical resources that enable successful crisis detection. However, it is often lower level personnel who actually sense the disruptive and changing landscape first since they interact daily with the systems and environment where these disruptive

[1] Woods, *Complexity: Advancing the State of Thought and Practice Across Navy, DOD, and the Federal Government.*

changes appear. Crisis detection can take multiple forms including identifying where the organization is most brittle, identifying gaps in transferrable resources, developing more realistic Most Dangerous Course of Actions (MDCOA), or establishing processes and structures to communicate more efficiently about potential disruptive changes. Any one of these actions could have strengthened the USS VINCENNES' capacity to detect and maneuver around the disruptive changes created by the presence of Iran Air Flight 655.

Second, since many disruptive changes are unavoidable, strong organizational resiliency helps organizations navigate through crises by ensuring adequate crisis preparation and response capabilities. This preparation is accomplished through robust crisis management planning and training. The four drivers of organizational resiliency should cause leaders and followers to collaborate on the development of more accurate MDCOAs, train to scenarios that stress-test performance in novel and routine tasks during crisis, and highlight where the organization lacks sufficient adaptive social or physical resources.

As the case study showed, strong organizational resiliency generates more accurate MDCOAs and helps leaders develop more adaptable decision-making structures and processes. These decision-making structures and processes include acquiring different perspectives, the ability to reframe problems that pose novel tasks, and the ability to activate different knowledge networks to solve crisis problems. For personnel responsible for routine tasks, strong organizational resiliency develops crucial procedures such as checklist adherence, redundancy and quality control mechanisms, and the capacity to employ escape strategies by bringing latent social or physical resources to bare on the crisis problems. In short, strong organizational resiliency ultimately helps Air Force squadrons navigate through crises because it affords better preparation for crisis through training and exercises. As Confucius notes "success depends upon previous

preparation, and without such preparation there is sure to be failure."

Future Research

One limitation of this study is that the concepts of organizational resiliency were only applied to one case study. More analysis is needed and thankfully the field of organizational resiliency has areas for future research. First, the concepts and framework developed in this study could be tested in a broader set of case studies. This will help elucidate whether the framework of organizational resiliency developed in this study has widespread applicability.

Second, more research is needed in the area of effective measurements of organizational resiliency, or what other disciplines sometimes call organizational fitness.[2] Some efforts are being made to develop models that assess organizational resiliency strategies utilized by organizations before disruptive changes occur instead of doing a post-mortem analysis afterwards.[3] However, variation across industries and the small number of case studies limit any current set of universal measurement standards.

Future research could include developing models that measure organizational resiliency within specific Air Force operational squadrons. Considering the complexity of the current operating environment, organizational resiliency is an important attribute that Air Force leadership should foster across its varying missions and levels of organization. SNAFU will remain an apt description of the complex world. The leadership challenge is learning to be comfortable amid complex chaos.

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[2] Sven C. Voelpel ‡, Marius Leibold, and Khalid M. Mahmoud, "The Organizational Fitness Navigator: Enabling and Measuring Organizational Fitness for Rapid Change," *Journal of Change Management* 4, no. 2 (June 1, 2004): 123–40, https://doi.org/10.1080/14697010410001687483.

[3] Alessandro Annarelli, Cinzia Battistella, and Fabio Nonino, "A Framework to Evaluate the Effects of Organizational Resilience on Service Quality," *Sustainability* 12, no. 3 (2020): 958.

Recommendations for Air Force Squadron Commanders

Despite its limitations, this study offers several recommendations based on the insights and arguments developed throughout. It is important to note that these recommendations are not exhaustive. Rather, they consist of principles and guidelines that can develop strong organizational resiliency.

#1 – Create a culture that expects disruptive change

Squadron Commanders, as Air Force leaders of socio-technical organizations, live in a world of complex adaptive systems (CAS). Organizations resist change and yet change is inevitable due to physical forces or changing social and physical technologies. Therefore, Squadron Commanders should take the following steps to foster a culture that expects and embraces disruptive change.

First, a Squadron Commander must empower everyone in the organization, especially those on the front lines of operations, to act as crisis-sensors. Individual Airmen must feel empowered to take the initiative in identifying and communicating potential disruptive changes. Specific steps fostering this form of initiative can include encouraging regular reporting from frontline crisis-sensors through the formal chain of command, ensuring representatives from all levels of the organization are present at key weekly planning and staff meetings, and infusing operations with frequent stress-tests to highlight where disruptive changes may occur.

Moreover, since social media platforms are changing how Airmen communicate and share ideas, and how leaders keep the pulse of their squadron, commanders should develop adaptive communication and operations capabilities using a variety of applications available today (Signal, WhatsApp, Facebook, Slack, Microsoft Teams, Desktop Anywhere etc.). Ultimately, establishing a culture that expects disruptive change requires having leaders that are willing to be adaptive in how the squadron conducts the mission and how the squadron generates and

communicates new solutions to emerging problems.

Second, a Squadron Commander should seek to structurally organize their squadron in a way that maximizes graceful extensibility. What this means in practice is favoring a networked approach to structure rather than merely a hierarchical structure. Networked organizations have better access to latent resources inside and outside of their organization which can be activated during times of crisis. Specifically, this means organizing the squadron to execute the mission through a series of small, self-sustaining networks. The exact form of this organizing principle will vary based on squadron missions.

For example, combat fighter squadrons are often organized around specific functions (scheduling, training, standardization and evaluations, weapons and tactics, security, and administrative offices) which enable the entire squadron to execute the mission efficiently from one location but require the majority of personnel to do it. Operations from more than one location significantly stress the organization's ability to execute the mission. However, great power conflict will likely involve significant disruptive changes that create high casualty rates while forcing squadrons to operate from many locations at once. In this environment, having a squadron organized in a more networked fashion consisting of smaller and agile distributed nodes will enhance survivability and mission execution. However, it requires rethinking traditional notions of squadron structure and embracing cross-functionality and distributed capabilities like EXERCISE Rapid Forge aptly demonstrated.

#2 – Identify areas of brittleness

Knowing disruptive change will occur is one thing. Knowing where it occurs is far more difficult. When it occurs in areas of brittleness, it threatens the continued functionality or survival of an organization, and therefore generates considerable stress which exacerbates organizational performance. The main mechanism for highlighting areas of brittleness is the development of accurate MDCOAs which, like all effective strategies,

require properly understanding the problem and contextual factors. Squadron Commanders should consider two things when assessing MDCOA as a means to highlight areas of brittleness.

First, Squadron Commanders need to ensure that proposed MDCOAs by their planning teams are actually accurate MDCOAs. To do this, several questions should be asked. Is the scenario suggested in this COA most dangerous because it involves uncertainty and time compression, or because it directly threatens the organization? Is the scenario suggested in this MDCOA a scenario the organization is currently equipped to handle and regularly trains against? Is the solution employed to handle the MDCOA dependent on a series of tightly coupled and interdependent systems working together in a flawless manner?

The answers to these questions will determine whether the MDCOA being offered by the planning team is, in fact, an accurate MDCOA. As shown in the case study, questions similar to these three would have revealed to the USS VINCENESS that an air attack by an Iranian fighter aircraft was not the MDCOA. Rather, correctly identifying an unknown track emerging from a dual use airport during an intense sea battle was a far more accurate MDCOA and would have exposed their areas of brittleness. This latter MDCOA involved far more uncertainty and time pressure, it was not a scenario the Middle East Task Force was well equipped to handle nor had the USS VINCENNES trained to this scenario at all, and finally, it required the near perfect execution of a series of tightly coupled and interdependent systems.

Second, Squadron Commanders need to assess whether sufficient adaptable resources are available to handle the MDCOA. If organizational resiliency is an adaptive capacity that allows organizations to maneuver in their operating envelope via resources that are malleable and transferable, then naturally, areas where no such adaptive resources exist to handle disruptive changes are areas of brittleness. For the case of the USS VINCENNES, this area was fighting a sea battle with ship

malfunctions while handling an air track out of a nearby dual use airport.

Adaptive resources can either be generated within the organization or activated via external networks. For instance, consider the following simple example. A formal flying training squadron, which is responsible for generating new fighter aircrew every six months, experiences significant delays with the current class due to weather and a global pandemic which requires significant social distancing. Sufficient adaptive resources include having sufficient extra aircraft, aircrew, maintenance parts, airspace, and support personnel that are transferrable to ensure course completion dates are met. These resources could be generated within the squadron or activated through network connections with other squadrons in the wing. However, in order to have adaptive resources available, commanders must balance being efficient with being adaptable.

#3 – Balance efficiency with adaptability

Developing the adaptive capacities to handle disruptive changes has implications for efficiency in operations. Efficiency ultimately involves maximizing productivity while minimizing unused resources.[4] However, prioritizing efficiency often works at cross-purposes with adaptability. If an organization is going to develop an adaptive capacity to anticipate, absorb, and respond to disruptive changes, it needs to develop a reservoir of adaptive resources ready to be activated regardless of whether these resources are human, material, or non-material. Simply put, you cannot be perfectly efficient and perfectly adaptable at the same time.

Consider the airline industry example used in Chapter Three. One of the primary reasons why Southwest Airlines successfully navigated

[4] Oxford University Press, "Efficient | Definition of Efficient by Lexico," Lexico Dictionaries | English, accessed April 10, 2020, https://www.lexico.com/en/definition/efficient.

the disruptive challenges posed by 9/11 compared with other airlines is because they maintained a business model that valued both relational and financial reserves.[5] They could have chosen to be more efficient with their resources, but then again, they would not have been as adaptive.

Again, consider the Rapid Force example used in Chapter Three. One of the primary purposes of the exercise was to develop cross-functional battlefield Airmen. These airmen, originally trained as security forces, fuel specialists, or communications specialist, were prioritizing adaptability over efficiency when they learned cross-functional skills. The 4th Fighter Wing leaders understood the importance of developing the adaptive capacity inherent in transferrable and malleable resources (cross-functional Airmen) given the myriad of disruptive changes presented to traditional Air Force operations by a great power conflict. In a great power conflict, airbases will be attacked, Airmen will die, and aircraft will have to operate in a distributed manner. Therefore, these leaders correctly identified the traditional stove-piped functionality of their Airmen as an area of brittleness. Cross-functional Airmen, while less efficient, improved graceful extensibility for these organizations during great power conflict.

#4 – Develop different strategies for novel and routine tasks in crisis

While this study argues organizational resiliency helps Air Force leaders anticipate and maneuver away from disruptive changes, it recognizes this is not always possible. Likewise, attempts to reduce stress generated by these disruptive changes through identifying brittleness, fashioning proper MDCOAs, and training to disruptive changes may not eliminate the presence of stress. Performance in crisis will likely be diminished for both novel and routine tasks. Therefore, leaders should develop different strategies for novel and routine tasks during crises.

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[5] Gittell et al., "Relationships, Layoffs, and Organizational Resilience."

As argued in Chapter Two, the negative effects of stress on novel task performance can be mitigated by the "step back" approach. This strategy suggests leaders should revisit assumptions, reframe the situation, create new procedures and routines to form new responses (e.g., improvisation).[6] This may involve changing organizational structure and decision-making procedures to handle the novel task at hand. However, the "step back" approach can be disastrous for quantity-induced crises that affect routine performance.

Recall from Chapter Two, continual and dynamic interruptions during routine tasks can generate a backlog of pending interruptions that need to be resolved. The system initially increases the resolution rate to handle this growing backlog, however, the continual interruptions can push the system towards an incipient inflection point which generates a negative feedback loop based on the system's maximum resolution rate being exceeded. What may be required in quantity-induced crises is a strict adherence to established procedures while employing escape strategies to diminish the accumulation rate.[7] As shown in the case of the USS VINCENNES, both of these strategies may be required simultaneously depending on the level of analysis.

For instance, the command team on the USS VINCENNES faced a novel task given the sea battle, ship damage, and proximate air threat. Yet, the entire Task Force did not have the adaptive resources to help the USS VINCENNES command team revisit core assumptions about the identification of Flight 655. Nor did Captain Rogers have the organizational process in place to leverage the "step back" approach within his adhoc three-ship organization. However, they likely could not have developed the adaptive capacities enabling a "step back" strategy without first identifying that the Task Force was brittle in the area of distinguishing between civil and military aircraft taking off from a dual-

[6] Rudolph and Repenning, "Disaster Dynamics," 25.
[7] Rudolph and Repenning, 25.

use airport during a sea battle.

Yet, the USS VINCENNES required a different strategy for mitigating the negative effects of stress on routine task performance. The crewmembers executing the routine function of detecting, identifying, and tracking Flight 655 needed to adhere to specific procedures regarding IFF reporting, altitude and range information, and communication standards. Additionally, employing escape strategies by offloading identification challenges or confirming altitude information with nearby ships would have helped reduce the stress generated by the myriad interruptions that plagued these crewmembers during the six-minute engagement period.

Ultimately, both the command team and the line crewmembers, required different strategies to mitigate the negative interaction between stress and performance. Understanding different coping mechanisms for novel and routine tasks in crises can help commanders craft specific plans for handling disruptive changes unique to their organizations.

These four recommendations serve as a solid starting point for developing organizational resiliency. Squadron Commander should waste no time in initiating the steps outlined in these recommendations because organizations go into crisis with the resiliency they have, not the resiliency they want. Ultimately, the adaptive capacity generated by strong organizational resiliency can be one of a Commander's most effective tools to meet their command responsibilities.

Air Force Instruction 1-2 lists four prioritized duties and responsibilities for every Commander: execute the mission, lead people, manage resources, and improve their unit. Strong organizational resiliency impacts each one of these responsibilities in a meaningful way. especially during times of crisis. Therefore, in a world where crisis is inevitable and you are responsible for Airmen and delivering air, space, or cyber power for the nation, how resilient is your organization?

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