



NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

MODELING INFORMATION GAPS IN MILITARY COMMAND STRUCTURES

by

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June 2019

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REPORT DOCUMENTATION PAGE			<i>Form Approved OMB No. 0704-0188</i>	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE June 2019	3. REPORT TYPE AND DATES COVERED Master's thesis	
4. TITLE AND SUBTITLE MODELING INFORMATION GAPS IN MILITARY COMMAND STRUCTURES			5. FUNDING NUMBERS	
6. AUTHOR(S) Joel M. Katz				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			10. SPONSORING / MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. Government.				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release. Distribution is unlimited.			12b. DISTRIBUTION CODE A	
13. ABSTRACT (maximum 200 words) Technological advances have led to an increase in data available to commanders and their staffs. Sorting through collected data and identifying what is present that is relevant and what is relevant-but-not-present is necessary to identify and eliminate information gaps that hinder a commander's decision-making ability. This thesis developed and assessed a model illustrating the creation and propagation of information gaps in a command structure in order to provide a tool to identify and mitigate organizational blind spots. Literature describing approaches to naturalistic decision-making; individual processes for collecting, filtering, and interpreting specific data; and the effect of staff member roles on their interaction with data formed the basis of the model. Internal analysis revealed potential causes of information gaps. The model's utility in identifying information gaps was evaluated using dissimilar historical cases with varying command attributes and environmental parameters including technological context, situational tempo, and level of war. The thesis concludes by describing the model's limitations and suggesting techniques to further validate the model using live exercises and a way to apply the model offensively in deception operations.				
14. SUBJECT TERMS decision-making, command and control, C2, dynamic model of situated cognition, naturalistic decision-making, recognition primed decision-making, sensemaking, knowledge transfer, organizational ignorance, information management, knowledge management, complexity, uncertainty, ambiguity, equivocality, hierarchy of command			15. NUMBER OF PAGES 87	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UU	

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MODELING INFORMATION GAPS IN MILITARY COMMAND STRUCTURES

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Submitted in partial fulfillment of the
requirements for the degree of

**MASTER OF SCIENCE IN INFORMATION WARFARE SYSTEMS
ENGINEERING**

from the

**NAVAL POSTGRADUATE SCHOOL
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ABSTRACT

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LIST OF ACRONYMS AND ABBREVIATIONS

ACE	Airborne Command Element
ATO	air tasking order
AWACS	Airborne Warning and Control System
C2	command and control
CFACC	combined forces air component commander
COA	course of action
COE	concept of employment
COP	common operating picture
CTF	combined task force
DA	Department of the Army
DMSC	dynamic model of situated cognition
FHW	<i>Fremede Heere West</i>
FUSAG	First United States Army Group
HUMINT	human intelligence
IE	information environment
IFF	identify friend or foe
IM	information management
IMINT	imagery intelligence
IMO	information management officer
KM	knowledge management
KMO	knowledge management officer
MAGTF	Marine air-ground task force
MCDP	Marine Corps doctrinal publication
MEF	Marine expeditionary force
NFZ	no-fly zone
OPC	Operation Provide Comfort
RAF	Royal Air Force
RPD	recognition-primed decision
SD	<i>Sicherheitsdienst</i>
SIGINT	signals intelligence

SS	<i>Schutzstaffel</i>
TAOR	tactical area of responsibility
USMC	United States Marine Corps
VID	visual identification

ACKNOWLEDGMENTS

I want to thank Steve Iatrou, my advisor, for his guidance and encouragement. He challenged me to ask hard questions and always provided an alternative perspective. Thank you, Dr. Kate Egerton, for your assistance in ensuring I presented my ideas in an intelligible and grammatically correct manner. Lastly, I want to thank Dr. Ray Buettner for his confidence in my process and allowing me freedom in my approach to this research.

Most importantly, I would like to thank my wife, Sara, for her constant support and endless patience during our time in Monterey. Her confidence in me enabled me to finish this work. I also want to thank our children for inspiring me to never stop learning. I cherish our breakfast table conversations about who was going to learn more in school each day.

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I. INTRODUCTION

A. BACKGROUND AND MOTIVATION FOR RESEARCH

To achieve an advantage in the information environment (IE) and remain effective decision makers, commanders must maintain a high level of situational awareness. This situational awareness is built from raw data collected, processed, and presented by staffs to commanders as actionable information. As technology advances, more data are available to commanders and their staffs, but the pace of warfare has not slowed. The United States Marine Corps (USMC) has recognized this increase in available data as the Marine Air Ground Task Force (MAGTF) becomes more connected: “[t]he MAGTF will typically generate a large amount of unstructured data associated with its interactions across all security domains” (2017, p. 34). More information has the potential to raise the commander’s situational awareness if managed effectively “[a]s this information is gathered and processed within the context of enemy, friendly, and neutral actions in the IE, a more comprehensive understanding of the IE is possible” (USMC, 2017, p. 34). More data do not directly translate to better decision-making despite this erroneous oversimplification by some researchers (Leedom & Eggleston, 2005). Knowledge and information management that enable a commander’s decisions require that “timely, relevant, and prioritized information is organized, accessible, and useable to the commander, staff, and MAGTF elements” (USMC, 2017, p. 28). Though, accomplishing this task is challenging.

The staff’s requirement to provide the commander with relevant and necessary information is not new; however, the task has become more complicated as the amount of available data increases. The challenge that exists is not in collecting the data but in sorting through it with limited time and identifying what is present that is relevant and what is relevant-but-not-present. As warfare evolves and the boundaries distinguishing domains of conflict blur, filtering collected data and sorting the refined information to identify gaps become more arduous and essential for commanders and their staffs. When commanders do not have the necessary information to make decisions because of a lack of data collection or deficiencies in the processes that refine it, catastrophic results can follow.

B. RESEARCH QUESTION, METHODOLOGY, AND PATH TO ANSWER

The existence of information gaps in command structures prompts the following research question:

- How does one model information flows in a command structure in order to identify information gaps and mitigate them?

The answer begins in Chapter II with an investigation of how experienced individuals approach decisions in their actual environment. Examination of the methods used in naturalistic decision-making, including Klein's (1999) recognition-primed decision model, provides insight into how individuals navigate novel situations. The chapter then reviews both the socio-cognitive processes described by Leedom (2003) that convert data into actionable information as well as the dynamic model of situated cognition (DMSC), developed by Shattuck and Miller (2006), which traces data as it is collected and transformed into information driving an individual's decision. The DMSC is then combined with Leedom's (2003, 2004) command hierarchy model and the effect of specific staff member roles on their individual decisions. This combination yields a model that illustrates the flow of data through a command structure to its refinement into actionable information for the commander. Chapter II concludes by analyzing the model for sources of information gaps using Zack's (1999) classifications of organizational ignorance. Commanders are unable to use all the data that exists in the environment to make decisions; therefore, some information gaps are unavoidable. This model aims to illustrate how information gaps are generated internally and how staffs can mitigate the effect of these gaps to ensure the commander has as complete an understanding of the environment as possible.

With the model constructed and internally analyzed for the sources of information gaps, the remainder of the thesis tests the model's utility in identifying the cause of information gaps using historical cases. Chapter III identifies the varying command attributes used to test the model and the environmental parameters within which the model should function. Seven examples from the two selected cases assess the model's functionality across rigid and ambiguous command relationships and in varying

technological contexts, tempos, and levels of war. The model applies to both the German military in World War II during its attempt to discover the location of the planned Allied invasion of Europe and the crews involved in the shootdown of two friendly helicopters following the first Gulf War. Chapter IV evaluates the model using these cases, traces critical elements of data that failed to reach decision makers, and attributes the cause of the information gap to those identified in Chapter II.

C. PURPOSE OF RESEARCH

The purpose of this research is to improve decision-making in the IE by determining the cause of information gaps and mitigating their effect. The result is a model that depicts the origin and propagation of information gaps in a command structure. Analysis demonstrates the model is a tool that when applied to existing commands aids in revealing information processing flaws and potential organizational blind spots. Chapter V concludes the thesis by describing the model's limitations and suggesting techniques to further validate the model using live exercises and a way to apply the model offensively in deception operations.

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II. LITERATURE REVIEW AND MODEL DEVELOPMENT

A. EXISTENCE OF INFORMATION GAPS

Commanders operating in the IE are not receiving the data and processed information needed to make decisions in their complex and dynamic operating environment. Identifying the infeasibility of processing all the stimuli that exist, Lippmann (1997) states that “the real environment is altogether too big, too complex, and too fleeting for direct acquaintance ... [a]nd although we have to act in that environment, we have to reconstruct it on a simpler model before we can manage with it” (p. 11). Flaws in this reconstruction motivate the development of a model to identify the sources of information gaps in a command structure. Literature indicates that actionable information fails to reach the commander not only due to lack of initial data collection but also and more notably due to mismanagement of information processing and flow through the organization. While both the absence of information and errors in its processing can produce gaps, Leedom (2004) notes that, often, information’s misinterpretation not lack of collection or access to it leads to errors in the decision-making process.

Information sharing processes are more to blame than a lack of technological capability. In the *Marine Air Ground Task Force Information Environment Operations Concept of Employment* (COE), the United States Marine Corps (USMC) identifies that the commander’s inability to maintain situational awareness degrades his ability to generate plans and synchronize operations, “the MAGTF commander has limited ability to maintain a coherent understanding of relevant threats, vulnerabilities, and opportunities across the IE; and has limited C2 [command and control] mechanisms in place to integrate disparate IE Ops capabilities holistically and dynamically across the MAGTF” (USMC, 2017, p. 1). The COE continues that while some actionable information and intelligence just does not exist, some is unorganized and dispersed across multiple internal and external organizations. Emerging technologies that enable the transfer of knowledge between military headquarters and other entities are motivating research into the processes of

sensemaking¹ and knowledge management (Leedom & Eggleston, 2005). The USMC recognizes the need to improve these processes. One of the USMC's (2017) solutions to ensuring the commander has the information he needs when he needs it is the development of a system called the running estimate to aggregate, process, and use intelligence data in near-real time. The fact that the USMC has identified the requirement for this type of system reveals a deficiency in the information flow through its sensors, systems, analysts, advisors, and commanders that is producing information gaps.

Coakley (1992) maintains that “[e]nsuring the proper flow of critical information among friendly forces is, therefore, an essential C2 function” (p. 14). Proper flow implies information reaches the right people on its way to the commander. Proper flow also implies timely flow, otherwise the information is of no use. Therefore, critical information, that which is accurate and necessary, must reach the appropriate people without delay. While analyzing the common operating picture (COP), Leedom (2003) describes deficiencies in the flow of information through command structures. He asserts while the COP should be central to information flow and processing because it aims to build situational awareness and streamline planning, it has failed to do so because the majority of its contents is unsorted, unvalidated, and unimportant to the decision makers. He reports that “the current generation COP has become an ‘information warehouse’ for enormous amounts of information—much of which is poorly organized and validated, difficult to search and exploit, and often of marginal relevance to military decision makers” (p. 2). Commands are mismanaging and misprocessing data, all in an untimely manner, creating information gaps that make commanders ill equipped to make adequate decisions. Identifying information gaps in order to fill them or mitigate their impact requires an analysis of the commander's decision-making process and the transformation of data into actionable information as it flows through an organization.

¹ According to Weick (1979), sensemaking requires visualization of one's enactment, or interaction, with the changing environment around them.

B. DECISION-MAKING MODELS

Historically, military doctrine has encouraged the use of a rational or analytical model for making decisions, which is useful primarily in sterile, non–real-world settings (Roth, 2004). Norwegian naval officer Rolf Roth claims that in military training “[r]ational analytical decision-making, based on comparison of quantitative operations, is the preferred decision method, and is primarily done by what is known as the estimate process” (Roth, 2004, p. 71). He concedes, however, that this model does not emphasize the human characteristics of intuition and creativity that are required in combat. A more applicable model for military commanders is one constructed from research on how individuals make decisions in a dynamic, real-world setting. Naturalistic decision-making focuses on exactly that.

An investigation into naturalistic decision-making studied by Klein (1999) and Orasanu and Connolly (1993) begins by identifying its roots in Bross’s devil theory model as a means for making decisions. In *Design for Decision*, Bross (1953) argues that the devil theory model evolved from the inability of decision makers to accurately specify the correct response given innumerable possible situations. He claims further that decision makers built a model guided by cultural values that dictated normal behavior and then enabled them to frame the information presented in previously unseen situations. Though Bross acknowledges that the basis for the cultural model was rooted in the superstitions of medicine men and attempts to appease invisible deities and devils, he maintains this practice of constructing a model to explain the cause and effect relationship between things without an apparent connection is still valid. Bross asserts that devil theory is still used in modern times but replaces devils with modern complexities to explain the unknown. The recognition-primed decision model developed by Klein (1999) enables individuals to manage situations they do not understand.

Klein (1999) asserts that, in the recognition-primed decision model, decision makers evaluate a situation by looking for similarities with previous experiences and then sequentially visualizing individual courses of action to determine feasibility instead of simultaneously comparing the strengths and weakness of multiple options. He states “[t]he emphasis is on being poised to act rather than being paralyzed until all the evaluations have

been completed” (p. 30). Klein developed the model from observations of experienced individuals approaching real world decisions in the naturalistic decision setting. Fundamental to the model is the fact that deliberation time is short and multiple options are assessed but not evaluated in parallel (Klein, 1999). The recognition stage of the process allows the decision maker to formulate applicable goals or desired outcomes, identify cues to assist in prioritizing information, generate expectations that confirm their approach to the situation, and produce typical responses that lead to potential courses of action (Klein, 1999).

Personal experience is crucial to successful use of the model. Klein (1999) asserts the ability to evaluate the feasibility of a course of action is based on experience, which is why the recognition-primed decision model works for experienced decision makers. In an earlier description of the model, Klein (1993) identifies two weaknesses: its limited use by inexperienced personnel and its inapplicability to situations requiring a deliberate comparison of options. He claims “the danger of misapplying recognitional decision strategies is that personnel will lack the experience needed to identify effective courses of action as the first ones considered, or will lack the ability to mentally simulate the option to find the pitfalls, or will fail to optimize when necessary” (p. 146). Multiple other researchers agree with Klein’s assessment of the recognition-primed decision model’s shortcomings.

Evaluating the recognition-primed decision model in the context of the military decision maker’s setting, Roth (2004) agrees with Klein (1999) that, in time-constrained environments, recognition-primed decision-making is useful. Holding that the recognition-primed decision model searches for the first feasible action rather than the best action, Roth (2004) maintains that “[u]nder immense time pressure, satisficing makes more sense” (p. 85). He continues that the model is not without flaws and not for use in all situations, particularly those which require an explanation of the decision or a comparison between two potential options. When using the recognition-primed decision model, “[j]ustification of decisions will be difficult in retrospect, and the method suffers from weaknesses in cases where competing interests needs *[sic]* to be evaluated” (Roth, 2004, p. 86). These factors

aside, Roth (2004) holds the model does have a place in most military decision applications.

In an appraisal of Klein's recognition-primed decision model along with eight other naturalistic decision-making models, Lipshitz (1993) identifies two key factors required to make the model useful: use by experienced decision makers and application in a time-constrained environment. Lipshitz maintains that it is more important for the decision maker to possess practical knowledge and experience in the area of the decision than exceptional analytical abilities. He asserts the decision maker's practical knowledge will enable "making finer distinctions and setting plausible goals within situations, drawing better analogies among situations, imagining richer potential developments, producing appropriate action, and recognizing inappropriate action more quickly" (p. 109). Lipshitz's appraisal of the recognition-primed decision model concludes by identifying the same two shortcomings as Roth (2004): its lack of utility in comparing multiple clear options and the difficulty it causes the decision maker in justification of their decision.

By analyzing the applicability of situational awareness in naturalistic decision-making, Endsley (1997) supports the validity of Klein's recognition-primed decision model. Endsley asserts that situational awareness involves perception, understanding, and future prediction of the environment, and that mental models possessed by experienced decision makers enable them to execute the process quickly. She claims experienced decision makers' "perceptions of the current state of the system may be matched to related schemata in memory that depict prototypical situations or states of the system model" (p. 274). The decision maker's mental model of the system described "provide [s]: (a) for the dynamic direction of attention to critical cues, (b) expectations regarding future states of the environment (including what to expect as well as what not to expect) based on the projection mechanisms of the model, and (c) a direct, single-step link between recognized situation classifications and typical actions" (Endsley, 1997, p. 275). These provisions are the same as Klein's (1999) list of by-products of the recognition stage in the recognition-primed decision model: "relevant cues, expectancies, plausible goals, and typical action" (p. 25, Figure 3.1). In a similar fashion to Klein (1999), Endsley (1997) asserts that the experience of decision makers will enable them to know what to look for and how to frame

it, evaluate whether things are unfolding in the manner expected, and immediately generate a potential response.

Some military doctrine includes the benefit of approaching decisions from a recognition-based approach because it fosters a bias for action. In the Marine Corps Doctrinal Publication (MCDP) 6, *Command and Control*, the USMC (1996) outlines a decision-making model similar to the recognition-primed decision model. Using this approach, commanders and staffs rely on pattern recognition and past experiences to assess current situations, which then enables them to develop workable options one at time (USMC, 1996). Klein's recognition-primed decision model yields a starting point for analyzing a commander's decision-making process in the information environment. To further analyze the inputs to the commander's process, one must investigate an organization's transformation of data to usable information.

In his research aimed at identifying how to transform the current COP from an unusable catalog of information into a tool assisting the conversion of data into decisions, Leedom (2003) identified the following required processes of commanders and their staffs: "information management, sensemaking, [and] knowledge creation" (p. 4). He asserts that when considering its role in decision-making, information management is more than cataloging raw data but entails the merging of "explicit/codified information (the 'know what') that reflects the operational environment and implicit/tacit knowledge (the 'know how') that interprets and transforms this information into action decisions" (p. 5). The article, "Organizing Knowledge" by Brown and Duguid (1998) holds that implicit knowledge is not easily transferred around an organization and is therefore harder to leverage. Leedom (2003) and Brown and Duguid (1998) agree that managing information includes managing not just an organization's data, but also the working knowledge of its personnel.

The second process Leedom (2003) claims is required for transformation of data into decisions is sensemaking, which he defines as "activities undertaken by an organization when it is faced with novelty or operational situations that do not conform to prior expectations" (p. 7). Leedom claims that effective sensemaking requires staffs to adapt to different types of information gaps. Differentiation between the types of

information gaps is essential. Zack's "Managing Organizational Ignorance" details the importance of an organization's ability to cope with four types of gaps defined as:

- Uncertainty: not having enough information
- Complexity: having to process more information than you can manage or understand
- Ambiguity: not having a conceptual framework for interpreting information
- Equivocality: having several competing or contradictory conceptual frameworks. (Zack, 1999, p. 354)

Zack's method for addressing these information gaps mirrors Klein's recognition-primed decision model. Zack continues that this requires recognition of the situation as a deviation from normal and then employment of sensemaking to enable the handling of the situation. This process parallels the recognition process described in Klein's recognition-primed decision model.

The last process Leedom (2003) lists is knowledge creation, which he defines as "a forward-looking process that focuses on problem-framing and problem-solving" (p. 10). He further claims that while sensemaking focuses on events that have already transpired, knowledge creation focuses on finding solutions. Knowledge creation facilitates decision-making by building bases of knowledge, means to distribute knowledge, and a record of where existing knowledge resides (Leedom, 2003). While Leedom (2003) focuses on describing the required socio-cognitive processes, Shattuck and Miller (2006) trace specific pieces of data flow to an individual's decision.

C. DYNAMIC MODEL OF SITUATED COGNITION

The dynamic model of situated cognition (DMSC) developed by Shattuck and Miller (2006) expanded the naturalistic decision-making process to incorporate inputs from sensors and the technological systems that process them. Their model (Figure 1) contains a series of ovals and lenses that represent the transformation of raw data into predictions of the environment by a decision maker.

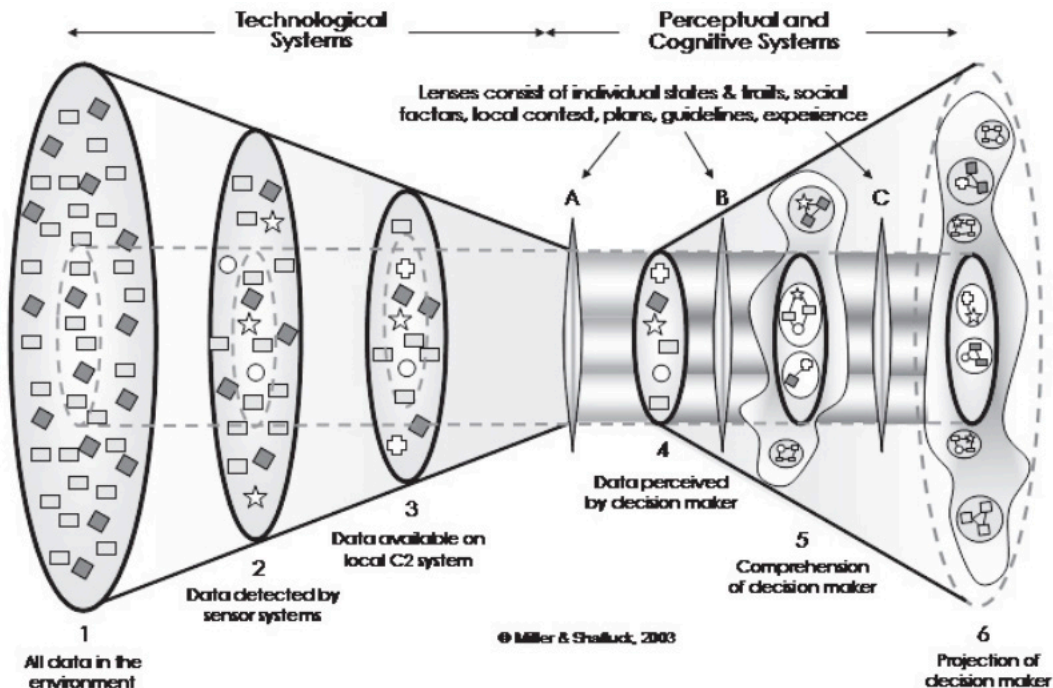


Figure 1. Dynamic Model of Situated Cognition.
Source: Shattuck and Miller (2006).

Shattuck and Miller (2006) describe oval 1 on the far left as a true, real-time picture of the entire operating environment. The authors use different colored shapes to depict various pieces of enemy, friendly, civilian, and environmental data. Oval 2 in their model depicts all that is collected by technological sensors. Shattuck and Miller (2006) point out that the transition from oval 1 to 2 is the first opportunity for the introduction of inaccuracies. They note that inaccuracies in oval 2 result from sensors' failure to detect data because of its lack of coverage, sensitivity, or specificity, or equipment failure or from its inaccurate classification of data due to enemy deception or incorrect algorithms. The authors highlight that these errors are likely unrecognized by the individuals using the sensor data. The third oval represents the data presented to an individual on their C2 display. The transition between ovals again allows for the introduction of data omission or inaccuracy due to "erroneous fusion algorithms, flawed filtering schemes, or poorly designed displays" (Shattuck & Miller, 2006, p. 7). Next are ovals 4–6, which are the cognitive representations of an individual's perception, comprehension, and future projection of the environment, each shaped by a lens that precedes it. Shattuck and Miller

(2006) assert that each lens is formed from six components of information that the individual internally possesses. In the model, the information resident in each lens combines with the contents of the oval to its left to form the oval to the right. The information in each lens follows:

- Individual states and traits
- Social factors
- Local context
- Plan
- Guidelines
- Experience. (Shattuck & Miller, 2006, p. 9)

In Shattuck and Miller's (2006) model, lens A forms an individual's perception of the environment (oval 4) by directing their attention to certain auditory and visual cues in oval 3 and away from others. The result is a smaller data perception oval than data displayed oval, as illustrated in Figure 1. Lens B enables an individual to make sense of the data perceived in oval 4 and transform it to comprehended or processed information in oval 5. The authors illustrate this by depicting the information in oval 5 as groupings of shapes. Shattuck and Miller (2006) assert that there are many ways that an individual could have comprehended the data perceived in oval 4 and represent that by placing other groupings of shapes outside oval 5, the individual's comprehension. Lastly, lens C drives creation of oval 6's contents, the individual's future projections. Just as there are alternative ways to comprehend the environment than that settled upon by the individual, there are even more alternative projections than those developed by an individual (Shattuck & Miller, 2006). Their model depicts this by placing even more groupings of shapes outside oval 6 than oval 5.

Shattuck and Miller (2006) address the accuracy of the comprehension and projection ovals' contents by asserting that errors introduced in ovals 1–5 propagate through the rest of the model. They claim that uncertainty can be present at any place in the model and that it is managed with varying competency by the supporting technological systems and the individual. Greater uncertainty results in larger comprehension and

projection ovals that may contain more than one possible arrangement of shapes (Shattuck & Miller, 2006).

Because the environment and one's comprehension of it continuously change, Shattuck and Miller (2006) incorporated feedback loops that represent the impact of decisions or actions by an individual on the ovals or lenses in the model. They developed feedback loops that emanate from the comprehension and projection ovals back to all the other ovals. The authors assert that decisions-made translated into actions-taken can affect the operating environment, oval 1, or the way it is detected or processed, ovals 2–4. Shattuck and Miller (2006) also describe a set of feedback loops emanating from the comprehension and projection ovals to each of the lenses by explaining that “[t]he comprehensions, projections, and decisions we make contribute to *the manner in which we view the world* [italics in original work]” (p. 11).

When applying the model to team interactions, Miller and Shattuck (2006) assert that ovals 1 and 2 are shared by all members and that ovals 3–6 are specific to each team member as depicted in Figure 2.

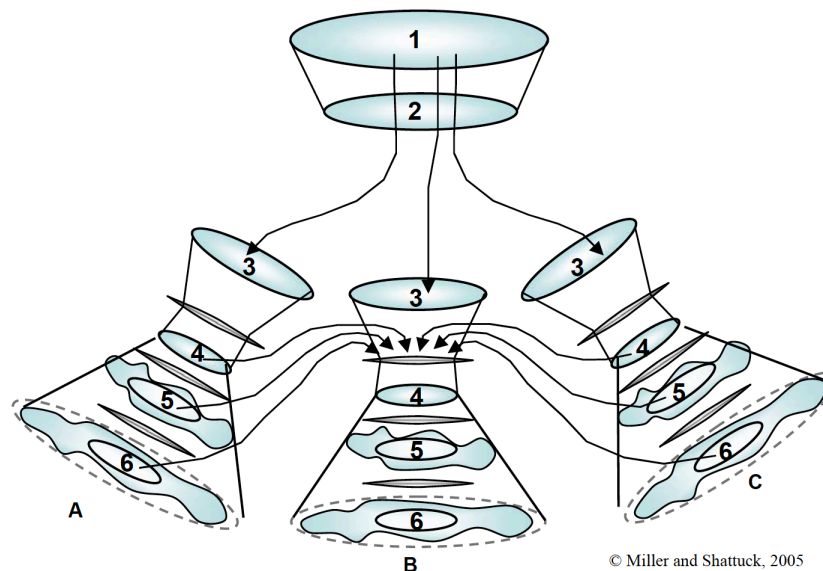


Figure 2. The DMSC Applied To Teams.
Source: Miller and Shattuck (2006).

Miller and Shattuck (2006) claim that a team member's interaction with other individuals who communicate their own perceptions, comprehensions, or projections of the situation must pass through that team member's lens A prior to further processing.

Shattuck and Miller (2006) describe an expansion of the individual DMSC to include multiple layers for each individual in the command hierarchy in their analysis of the USS *Greenville's* collision² with the Japanese fishing vessel *Ehime Maru*. They describe the interactions between the DMSCs for the commanding officer, officer of the deck, and other bridge personnel during the catastrophic event. Extending the investigation of data transformation and information flow from a single individual to the hierarchical structure of command organizations warrants review of Leedom's (2004) report *The Analytic Representation of Sensemaking and Knowledge Management within a Military C2 Organization*. He explains that members of a command structure interact with and have different use for data, information, and knowledge. He continues that as the individual's role changes from simply collection and analysis, or problem solving and managing, to establishing an overall campaign direction their effect on information differs also (Leedom, 2004). In terms of Shattuck and Miller's DMSC, the role each member fulfills affects the contents of their lens and the start and end points of their feedback loops.

D. HIERARCHY OF COMMAND STRUCTURE MODEL

Leedom (2003) and (2004) presents a simple organizational model to represent the hierarchy of a command structure and the effect of decisions at each level. He states the importance of decisions at every level; "[w]hile it is true that decision making responsibility and authority ultimately reside with the commander, other individuals within a command organization contribute to various levels of the decision making process" (Leedom, 2003, p. 16). He models the command organization as a hierarchy of three levels: the commander, principal advisors, and support staff. Each level is responsible for their own roles which shape their interactions with information and affect its flow (Leedom, 2003). The model is visually depicted in Figure 3.

² Shattuck and Miller (2006) describe the fatal sinking of the Japanese fishing vessel *Ehime Maru* after the submarine USS *Greenville* collided with it while performing an emergency surface exercise.

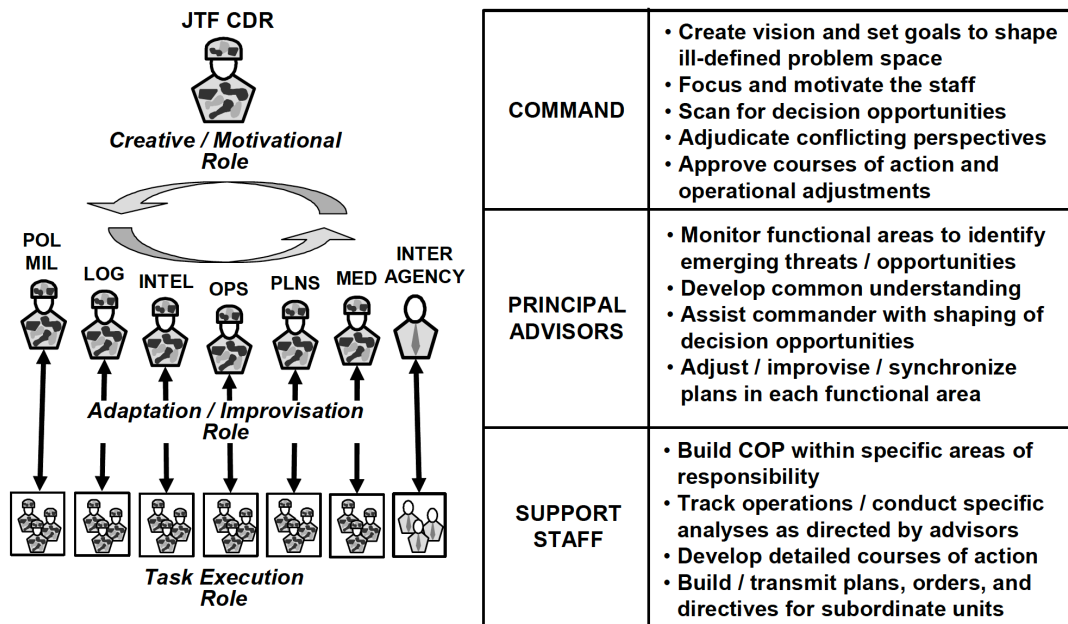


Figure 3. Decision Making Levels within a Military Command Organization. Source: Leedom (2003).

Assessment of each layer yields insight into the contents of each layer's lenses and the interaction of their feedback loops. Leedom (2003) summarizes each layer's roles in following manner. He claims the commander's primary role is to dictate command direction and set goals or objectives to limit or organize the framework of a developing situation. One level down, the principal advisors for each functional area adapt and improvise to match the commander's direction with what actually exists in the operating environment (Leedom, 2003). At the bottom, he explains that support staff executes specific tasks such as information management and intelligence analysis. To place Leedom's construct in USMC terms, one can envision principal advisors as the primary department heads such as the S-3 operations officer, S-4 logistics officer, and S-2 intelligence officer. The support staff can be envisioned as the technical specialists that support the department heads. Examples include operations clerks who track friendly position reports, embarkation specialists who study load plans, and intelligence analysts who pore over imagery and collection data. The number of principal advisors under the commander and the number of technical specialists subordinate to each principal advisor

can vary. Assigning three to each level for the purpose of this thesis will allow for adequate simplification while still understanding the dynamics that multiple entities at each level bring.

E. COMMAND DYNAMIC MODEL OF SITUATED COGNITION

Combining Shattuck and Miller's (2006) DMSC, their notion that each individual model affects those around it as in their USS *Greenville* example, and Leedom's (2003) three-tiered command hierarchy model allows for adaptation of the individual DMSC into a command DMSC as depicted in Figure 4.

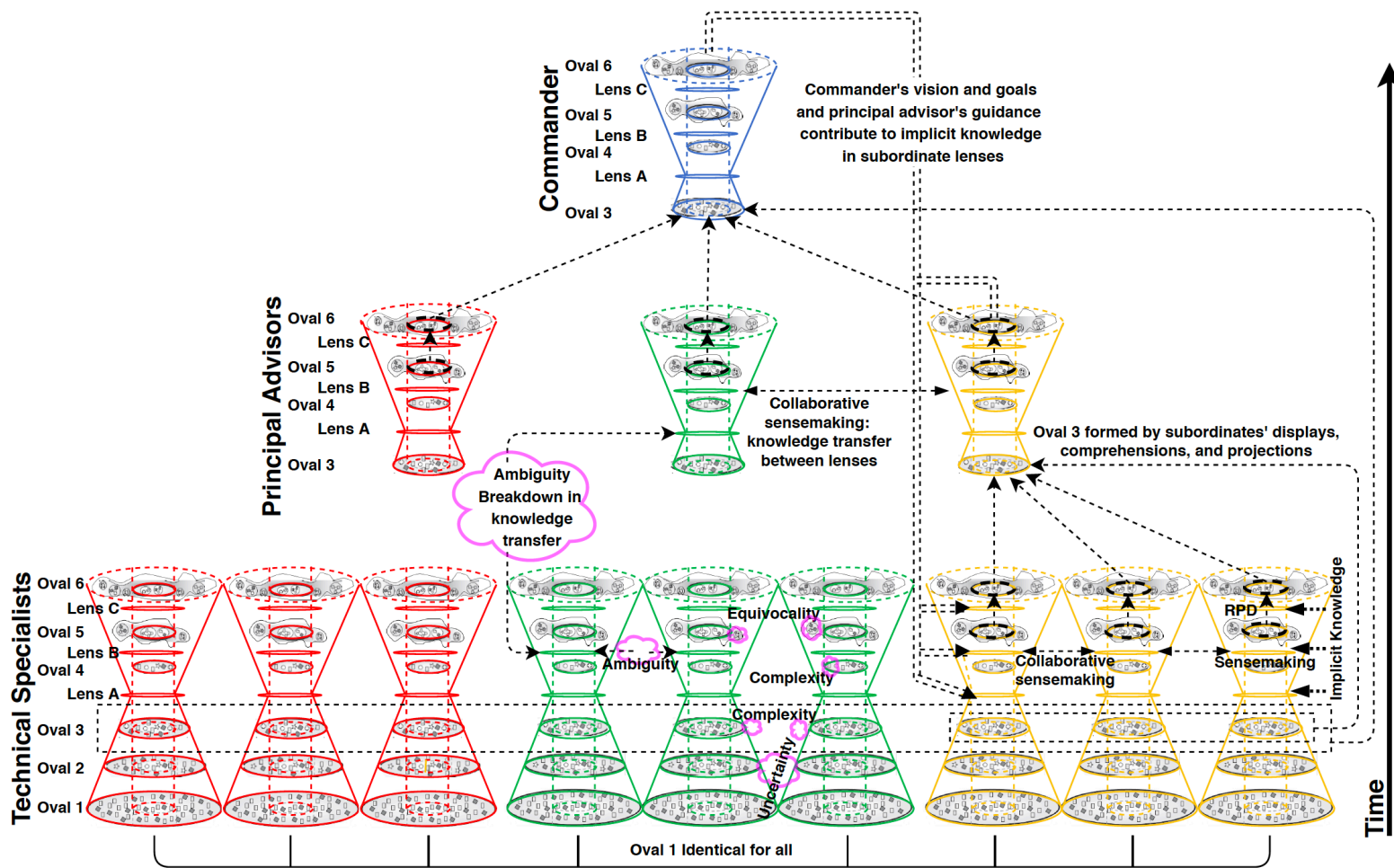


Figure 4. Command Dynamic Model of Situated Cognition. Adapted from Leedom (2003), Leedom (2004), Shattuck and Miller (2006), and Zack (1999).

In a vertically stacked DMSC for a command organization, each individual possesses their own series of ovals and lens as described by Shattuck and Miller (2006) with the following modifications. Each series of ovals on the bottom layer belongs to one of the principal advisor's technical specialists. Each series of ovals in the middle layer belongs to one of the commander's principal advisors. The colors red, green, and yellow represent different functional areas of the staff. The series of ovals on the top layer belongs to the commander. Leedom and Eggleston (2005) assert that "[i]nformation is exchanged primarily to increase the situation awareness of others in a bottom-up fashion, whereas positions are exchanged primarily to expand or modify the hypotheses held by others in a top-down fashion" (p. 4). The rotation of the of the DMSC from Shattuck and Miller's (2006) horizontal orientation to a vertical orientation represents the command's upward flow of information and downward flow of guidance and direction.

Starting at the bottom right of Figure 4, the individual DMSC for three technical specialists underneath a single common principal advisor are depicted in yellow. The contents of oval 1 remains the same for each of these three technical specialists, and in fact for all technical specialists, because it is an instantaneous depiction of the actual environment. Miller and Shattuck (2006) state that "[o]val 1 will be identical for any and all individuals involved" (p. 5). In contrast to Miller and Shattuck's (2006) application of the DMSC to teams in which oval 2, containing the data collected by technological sensors, was shared by all team members; each technical specialist in the command DMSC maintains their own oval 2. While describing how organizations learn about their environments, Pfeffer and Salancik (2003) assert that each individual's exposure to the environment and the framework with which they approach it leads to a diversion of ovals. They explain that "[i]t is also necessary to recognize that individuals and subgroups within organizations do not access the same environments and that the information they have varies. Individuals and subgroups have their own goals and activities that may bring them into contact with different aspects of the organization's environment" (Pfeffer & Salancik, 2003, p.74). Each specialist is responsible for different sensors that may or may not overlap in coverage. Miller and Shattuck (2006) describe a similar situation in which team members of differing coalition nations maintain different oval 2s because of a lack of intelligence sharing. The command DMSC expounds on that idea.

According to Leedom (2003), each specialist is responsible for a specific area; thus, each will have access to and control of different sensors.

Consider, for example, three intelligence analysts in an intelligence shop responsible for signals, human, and imagery intelligence respectively. The sensors that facilitate each are extremely different from each other and will detect different components of oval 1. An additional difference from Shattuck and Miller's (2006) DMSC worth noting is the possibility that the sensors that build oval 2 may not be exclusively technological. The auditory function of a human source will feed into oval 2 of the technical specialist responsible for human intelligence (HUMINT) even though it is not an electronic device. Continuing up the command model, oval 3 for each technical specialist differs because it is a display of the data from each collection sensor, not a complete synthesis of every collection entity available to the command. The six components listed by Shattuck and Miller (2006) that form lenses A, B, and C are part of that individual's "implicit/tacit knowledge (the 'know how')" described by Leedom (2003, p. 5). Specialists perform sensemaking during the transition from oval 4 to 5 and start the process by performing the recognition stage of Klein's (1999) recognition-primed decision model. Klein (1999) lists personal experience as a prerequisite for effective use of the recognition-primed decision model. If their experience is lacking (i.e., there is a deficiency of implicit knowledge in lens B), they can solicit the help of other technical specialists or their principal advisor and engage in collaborative sensemaking to leverage all the functional area's collective implicit knowledge. This transfer of implicit knowledge, which Leedom (2003) believes is part of knowledge creation, adds to the contents of the individual's lenses, reshaping them. In the transition from oval 5 to 6, specialists performing recognition-primed decision-making using the contents of lens C to generate future expectations. These expectations allow an individual to confirm their comprehension in oval 5 was accurate and serially perform mental simulation of potential actions to evaluate their feasibility. Again, if a deficiency in their lens C inhibits this, they can enhance their lens C through the process of knowledge transfer.

The middle series of ovals represents the DMSC for the principal advisors. Because their role, as described by Leedom (2003), is to oversee the collection of information and execution, their model starts at oval 3, the local C2 system. The principal advisor's C2 system

differs from the technical specialist's C2 system, which consists of the software and hardware sets that display technical data described in Shattuck and Miller's (2006) original model. While the principal advisor's oval 3 contains all of those work stations that the principal advisor has access to, as depicted by the dashed line around all the subordinate oval 3s, it also consists of his subordinate technical specialists' comprehensions and projections. These are communicated verbally and visually through briefs from maps or slideshows and written reports. The dashed lines from the specialists' ovals 3, 5, and 6 to the principal advisor's oval 3 in Figure 4 depicts this. The command DMSC injects human interaction in a different location than Shattuck and Miller's (2006) original model. Miller and Shattuck (2006) assert that human interaction in the form of comments from another individual about their own perceptions, comprehensions, and projections enters the subject's model between oval 3 and lens A and must be processed by the lens A before it can affect the subjects perception, comprehension, and projection. Figure 5, from Miller and Shattuck (2006), depicts that interaction.

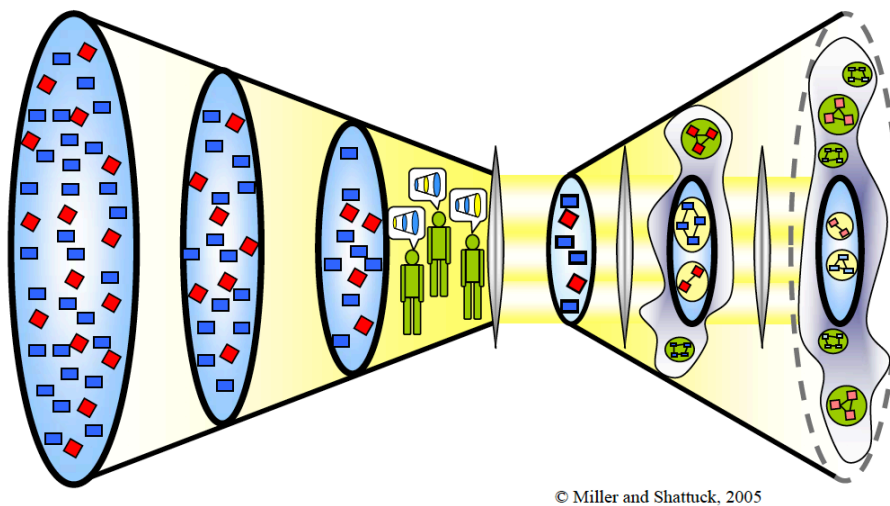


Figure 5. Input from Humans Enters the DMSC at Lens A. Source: Miller and Shattuck (2006).

This placement works for interactions with peers and fellow team members; however, the technical specialists that work for a principal advisor are his C2 system, not side commenters. Just like electronic sensors at a technical specialist's disposal may or may not detect and correctly or incorrectly classify data points from the environment for presentation on the technical specialist's oval 3, those same technical specialists may or may not detect and correctly or incorrectly classify information for presentation to the principal advisor. Essentially, the technical specialists form some of the principal advisor's sensors. Like sensors, they can be redirected, become obscured, have flaws, and misidentify data. The data on the principal advisor's oval 3 then propagate up through the lenses to form his projections. Just like the technical specialists, a principal advisor lacking implicit knowledge in a lens to perform sensemaking can refine that lens through knowledge transfer from fellow principal advisors. The impact a technical specialist has on the principal advisor is shaped by his physical or virtual presence. A specialist present on the watch floor will communicate differently than one who is at another geographic location and working remotely. Similar to the technical specialists' lenses, the principal advisors' lenses are shaped by his role in merging the commander's vision with the developing situation while maintaining awareness of their functional area's relationship with others (Leedom, 2003).

The top series of ovals represents the DMSC for the commander. His model resembles that of the principal advisor and starts at oval 3, the local C2 system. The commander's C2 systems is even larger though. It consists of all the technical specialists' work stations the commander has access to view to on the watch floor and the verbally or visually communicated comprehensions and projections of his principal advisors. These verbally and visually communicated comprehensions and projections often take the form of commander's update briefs, course of action briefs, and mission confirmation briefs. These tend to be more formal and one-way than the interactions between an advisor and specialist at a working group, planning cell, or spontaneous watch floor conversation. The manner in which the it is presented (i.e., how it exists on the commander's oval 3) affects its detection by lens A and existence on oval 4. Shaping the commander's lenses is his role of setting the vision and problem framework (Leedom, 2004).

F. INTERNAL VALIDATION OF THE COMMAND DYNAMIC MODEL OF SITUATED COGNITION

The command DSMC can be scrutinized for information gaps as pieces of data transit through the command and transform into information through the processes of sensemaking and knowledge transfer. Information gaps exist when the commander does not receive a specific piece of necessary information required for a decision. These appear in the model as an essential shape or grouping of shapes not ascending to the next oval. The gap can be the result of an information deficiency, the shape not being included in the next higher oval, or as a result of a processing time delay, the shape has not moved quickly enough to reach the commander when he needs it. While the command model presents a snapshot in time just like Shattuck and Miller's (2006) model, the vertical time axis on the right side of the model in Figure 4 illustrates the time required for information to flow through the levels.

Identifying and mitigating information gaps requires a framework to classify them. In the article "Managing Organization Ignorance," Zack (1999) asserts that an organization's management of what it does not know, defined as organizational ignorance, is more critical than what it does know. Zack's (1999) four types of organizational ignorance yield a starting point for investigating the existence of information gaps in the command DMSC.

1. Uncertainty

Zack (1999) describes uncertainty as "not having enough information to describe a current state or to predict future states, preferred outcomes, or the actions needed to achieve them" (p. 357). Uncertainty is first evident in the transition from oval 1, that which is present in the real world, to oval 2, that which is detected by sensors. Shattuck and Miller (2006) illustrate the potential causes of missing or inaccurate data ascension from oval 1 to ovals 2 and 3 in Figure 6.

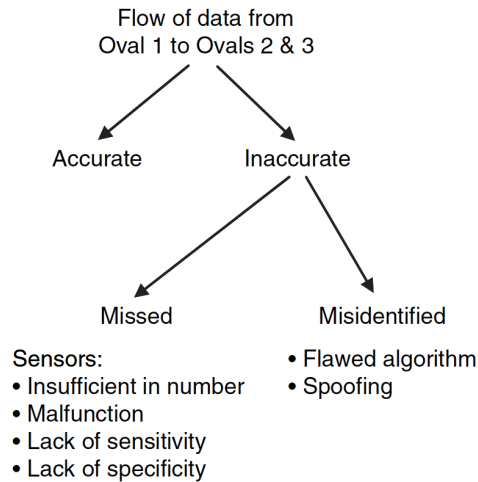


Figure 6. Gaps in Ovals 2 and 3. Source: Shattuck and Miller (2006).

Pfeffer and Salancik (2003) agree that the data collection abilities of an organization are finite, because “[t]he collection of certain information occupies the time and attention of the organization, which necessarily restricts the time and attention devoted elsewhere” (p. 74). The selection of data from oval 1 that is detected and ascends to oval 2 may be motivated by the ease with which it is collected (Pfeffer & Salancik, 2003). This leaves obscure and challenging to obtain data uncollected. Data from oval 1 can also be missed due to sensors being misdirected or focused on incorrect objects. The technical specialist’s misunderstanding the principal advisor’s tasking or the principal advisor’s misunderstanding of the commander’s guidance can cause this. The lenses of both the specialist and the advisor will shape their reception of guidance from superiors and may result in sensor misdirection. Another cause for misdirection of sensors stems from a functional area’s desire for self-preservation and self-promotion, Pfeffer and Salancik (2003) assert that “[o]ne would suspect that subunits, which are themselves concerned with their own survival and power in the organization, would collect information which enhances their own value in organizational decision making or which convinces others in the organization that they have information needed for organizational problems” (p. 77). This may not be intentional, as it is natural to elevate the importance of one’s area of responsibility above others.

When assembling the multiple DMSCs in parallel to represent multiple technical specialists underneath the commander's principal advisors as described by Leedom (2003), one can see gaps between the oval 2s of each technical specialist. Shattuck and Miller (2006) explain that "since decision makers usually do not know where the 'holes' are in the friendly and enemy sensor coverage, they are ignorant of how their mental model differs from the actual activities and events of the environment" (p. 8). These information gaps can be the result of inadequate coordination of the area of focus for each technical specialist's sensors or misinterpreted commander's guidance funneled through the principal advisor that directs each area of focus. These are all sources of information gaps, triggered by uncertainty namely a lack of data passing from oval 1 to oval 2. Regardless of what orients the direction of the sensors, a gap will exist as illustrated by the pink circle labeled uncertainty in Figure 4.

2. Complexity

Zack (1999) defines complexity as "having to process more information than you can manage or understand" (p. 354). Management occurs in the transition of data from ovals 2 to 4, while understanding occurs in the transformation of data into information between ovals 4 and 5. The sheer quantity of data and information present can result in its mismanagement and imperception by the commander and his staff leading to complexity-rooted information gaps. Complexity presents as mismanagement between ovals 2-4 and inattention in the transformation from ovals 4-5.

The vast amount of raw data collected by a technical specialist's sensors cannot all be presented on oval 3's visual displays and audio alert systems. Deliberate and undeliberate filtering occurs, resulting in inaccuracies in the technical specialist's oval 3. Shattuck and Miller (2006) discuss the sources of error in oval 3, explaining "the technology embedded in the local C2 system may misrepresent, through erroneous fusion algorithms, flawed filtering schemes, or poorly designed displays, what is present" (p. 7). They maintain that filtering is often unconscious, a result of a workstation software's design. It can also be a conscious decision though, the specialist's decision to only display a certain type of data. This decision is influenced by the same factors forming lenses A, B, and C such as the job description and responsibilities of each specialist, the current mission, and feedback from the commander or

principal advisor containing their vision of the current operation or environment. Omission of required data, either known or unknown, will cause information gaps depicted by the pink circle by oval 3 in Figure 4.

Information gaps result from filtering occurring between the technical specialists' ovals 5 and 6 and the principal advisors' oval 3 and one layer higher, between the principal advisors' ovals 5 and 6 and the commander's oval 3. The less effort required to process, present, or communicate data and its potential to improve its holder's status motivates its collection (Pfeffer & Salancik, 2003). These characteristics, ease of handling and power in ownership, can also drive specialists' and advisors' selection of information from their ovals 5 and 6 to form their superiors oval 3. Similarly, commanders and advisors are also motivated to collect from their subordinates that which is easily presented and communicated. This may result in the omission of the intricate yet pertinent for the simple but irrelevant.

Complexity also exists in the transition from oval 3 to 4. Individuals can only absorb a certain amount of data available on the local C2 system. Pfeffer and Salancik (2003) point out that because human perception is limited, there will always be data that are overlooked. Of the six information classes forming lens A described by Shattuck and Miller (2006), experience and guidelines can cause flawed filtering. They claim that an individual's use of specific types data in the past, their experience, can bias them to pay attention to it in the current situation. Pfeffer and Salancik (2003) note that an organization's standard operating procedures can also influence what is perceived from oval 3: "[t]he fact that certain information is regularly collected focuses the organization's attention on it" (p. 74). This occurs at all levels of the model. A specialist will pay attention to a specific type of data on his workstation that is regularly collected because he is familiar with the source and format. A principal advisor in a working group or planning cell will seek out updates to data discussed at a previous meeting. A commander receiving a daily update brief will compare data points from the current briefing to the last briefing. While focus on the same type of data used previously may be required in the current situation, it can also lead one to ignore relevant new types of data.

Expectations can also cause errors in filtering. Coakley (1992) acknowledges that "[t]he unexpected fact, while conveying more information, also is less readily absorbed than

something expected” (p. 99). Shattuck and Miller (2006) assert that expectations contained in the lenses can direct the focus of an individual toward data that support those expectations. Pfeffer and Salancik (2003) state that because one’s attention is limited to a single item, one can only perceive a single item at a time. Errors can be introduced when “people fill in what they expect to perceive” (Pfeffer & Salancik, 2003, p. 72). This is manifest in the model as someone not detecting a shape, a specific triangle, for example, in oval 3 because they are paying attention to other shapes. They then fill in that space in oval 4 that should have been occupied by the triangle with an incorrect shape they expect should be there.

The tendency of humans to accept the validity of information in written form or presented on a display over that information communicated through human interaction leads to further flawed filtering between ovals 3 and 4 at all layers (Johnson & Levis, 1988). This can cause commanders and principal advisors to place greater confidence in the accuracy of the COP or briefing slides than they do in the verbal statements from their staff. The result is inattention to information that is only verbally presented because it was not processed in time for inclusion in visual briefing products. Additionally, a commander or advisor is more likely to fill oval 4 with data seen on a watch floor display than data received from a sidebar conversation. This bias in lens A or B could lead to imperception of parts of oval 3’s contents or incorrect comprehension of oval 4’s contents.

Lastly, complexity presents in the transition from oval 4 to 5. The time constraints paired with the sheer quantity of data in oval 4 will limit an individual’s ability to process data even if they possess the implicit knowledge to do so. While Shattuck and Miller (2006) demonstrate that there are multiple ways to comprehend or group data into information in oval 5, data can also fail to ascend from oval 4 to 5 for two reasons. Data can fail to ascend because of the quantity of data perceived and an artificial or actual time shortage to process it all or because of a lack of tacit knowledge in lens B to understand the data. This is defined as ambiguity and is the next topic of discussion.

3. Ambiguity

Zack (1999) defines ambiguity as “the inability to interpret or to make sense of something” (p. 358). He explains that when experiencing ambiguity, “[e]vents are perceived

as so new and unfamiliar that one cannot even make a vague guess about what is important or about what may happen” (p. 358). He claims this is the result of a lack of framework enabling comprehension or understanding of the situation or generation of amplifying questions. When trying to convert data into consumable form, “pieces that don’t fit tend to get reshaped or dropped out” (Coakley, 1992, p. 78). Coakley maintains that outliers that would serve to identify data collection or processing errors or novelty in the current situation are discarded or negated.

Ambiguity is present in the command DMSC when information fails to ascend from oval 4. Data in oval 4 that cannot fit within the expectation or framework of lens B is absent or misrepresented in oval 5. If the implicit knowledge to understand a piece of data’s context and impact on its current environment is lacking, that piece of data will not ascend to oval 5 or 6. Difficulty in sensemaking stemming from insufficient implicit knowledge triggers the need for knowledge transfer. The merging of explicit information, data in one individual’s oval 4, with tacit expertise or implicit knowledge in another individual’s lenses B and C, allows for the accurate ascension of information to the decision maker (Leedom, 2003). Information gaps occur when the two are unable to merge as depicted by the pink circle labeled ambiguity in Figure 4. For example, technical specialist “A” may possess a piece of explicit data, a square in oval 4, but not the implicit knowledge in lens B to process it. Technical specialist “B” may not possess that piece of data in his oval 4; however, he does have the implicit knowledge in his lens B to process it. In order for technical specialist “A” to make sense of that data, the two must collaborate and knowledge transfer must occur. Davenport and Prusak (1998) and Zack (1999) agree that collaboration is most effective if is informal and conducted in person.

While describing how knowledge is transferred, Davenport and Prusak (1998) identify several barriers to knowledge transfer that originate in an organization’s culture:

- Lack of trust
- Different cultures, vocabularies, frames of reference
- Lack of time and meeting places; narrow idea of productive work
- Status and rewards go to knowledge owners

- Lack of absorptive capacity in recipients
- Belief that knowledge is prerogative of particular groups, not-invented-here syndrome
- Intolerance for mistakes or need for help. (p. 97)

These barriers can impede lateral or vertical knowledge transfer. Unfamiliarity or lack of regular interaction may introduce distrust (Leedom, 2004). Consider two intelligence analysts with the same experience level, but one is new to the command. Questionable confidence in his abilities may prevent the other from approaching him for assistance processing data in oval 4. The different training and backgrounds of two analysts will hamper communication between them and impede their ability to transfer knowledge contained in their lenses. A products-now environment will discourage individuals from seeking out someone who may understand things better. When the members of a functional area spend the majority of their time in scheduled meetings or briefings, their capacity and motivation to engage in the informal conversations that facilitate knowledge transfer is limited. A boss who regularly values the first person with the answer over team players may create a cutthroat environment further impeding transfer. Leedom (2004) adds two additional barriers that hinder knowledge transfer when collaborating remotely:

- *Inadequate expressive power provided by collaboration tools* (constrained message formats or lack of expressive tools) and
- *Inadequate or unreliable connectivity* (inadequate bandwidth or access to intranet). (p. 91)

Examples of these include a staff needing video conference or voice communications when only messaging is available or having a poor connection due to field conditions or shipboard limitations. A lack of appropriate security clearance for all entities creates additional barriers to effective knowledge transfer. The presence of these in an organization hinders knowledge transfer and allows for the creation of information gaps.

4. Equivocality

Zack (1999) defines equivocality as “having several competing or contradictory conceptual frameworks” (p. 354). The parallel structure of the individual DMSCs in the

command model can result in overlap of some of the ovals. For example, if the responsibilities of technical specialists are closely related, significant overlap can exist between ovals 2 through 4. Zack's definition of ambiguity is evident when the same perceived information is grouped differently in the comprehension and projection ovals of different individuals. Shattuck and Miller (2006) hold this is the result of differences between each technical specialist's lens B. The amorphous shape surrounding oval 5 "suggests there are other possible ways the data could be linked and reorganized that would lead to alternative mental representations of the data" (Shattuck & Miller, 2006, pp. 9–10). Weick (1995) states that sensemaking, the process enabling the transition from oval 4 to 5, is retrospective and driven by plausibility not veracity. This characterization of sensemaking allows for multiple interpretations of the same data; some of which are not correct. Hence, equivocality is the multiple different groupings of information in ovals 5 and 6.

A Venn diagram with varying amounts of overlap (Figure 7) illustrates this.

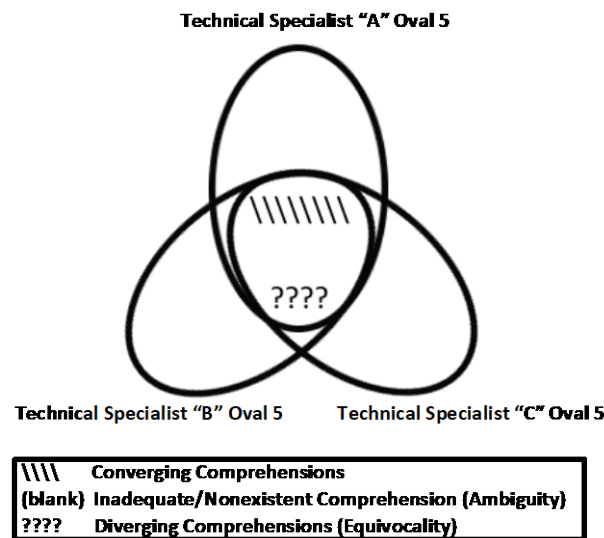


Figure 7. Oval 5 Overlap. Adapted from Shattuck and Miller (2006), Weick (1995), and Zack (1999).

Each oval represents each technical specialist's comprehended information, oval 5. The intersection of the ovals represents information that is shared by multiple specialists; however, there are differences between each specialist's comprehension. Inside the area of

overlap there are converging comprehensions, represented by backslashes. These are agreed upon by all members of the functional area and are presented to the principal advisor as a single, likely accurate, comprehension of the environment. The area of overlap also contains areas of inadequate comprehension represented by blank space. This empty space should have been filled by information derived from data that were unable to be processed due to lack of implicit knowledge in lens B. Lastly, the area of overlap contains diverging comprehensions represented by question marks. If multiple members of a functional area are tasked with preparing a brief, the presence of multiple diverging comprehensions will delay the flow of information to a principal advisor. The diverging comprehensions must either be resolved, or both will be passed up the model. Multiple contradictory comprehensions presented to the principal advisor will require filtering and slow processing resulting in information gap produced by the time delay.

Increasing the number of ovals in the Venn diagram will lead to additional equivocality. The command DMSC only places three specialists under each adviser and three advisers under the commander. Equivocality-based information gaps increase directly with the number of individuals processing the same perceived data.

G. SUMMARY

Flaws in the processes that transform data into useable information for decision makers result in information gaps. The command DMSC, adapted from the existing work of Shattuck and Miller (2006) and Leedom (2003), creates a visual depiction of data ascension through a command and the cause of some data's failure to ascend. The sources of these information gaps can be classified using Zack's (1999) framework for organizational ignorance: uncertainty, complexity, ambiguity, and equivocality. To ensure the model is a useful tool for modern command structures and not just a theoretical construct, practical validation of the command DMSC's ability to identify information gaps is required.

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III. METHODOLOGY

The command DMSC was constructed to illustrate the flow of data through a command organization and its conversion into actionable information for the decision maker. Analysis of the command DMSC for the creation of information gaps revealed four sources of those gaps: uncertainty, complexity, ambiguity, and equivocality. These sources were described in Chapter II, VI and illustrated in Figure 4. Chapter IV of this thesis will apply the command DMSC to seven examples in two dissimilar historical cases to assess its ability to identify information gaps across a wide range of command structures and operating environments.

A. CASE SELECTION CRITERIA

The command DMSC's utility in identifying information gaps should be thoroughly tested using both a rigid, hierarchical command structure and a more fluid, ill-defined command structure. The command DMSC must be able to handle the unique attributes of both types of commands. Additionally, the command DMSC should be functional across the spectrums of several environmental attributes. Application of the model to past and modern examples will demonstrate its effectiveness in a variety of technological contexts, showing it can still apply as technology evolves. Use of strategic and tactical cases will assess the model across the various levels of war. Lastly, applying the model to situations with a wide range of tempos in which the time it takes data to ascend the model ranges from months to minutes will further evaluate its versatility.

Selecting cases on both ends of the described environmental spectrums will enable a determination of the model's validity in identifying the sources of information gaps and how they propagate through a variety of command structures. The first case applies the model to the German military as it sought to discover the location of the Allied invasion of Northern Europe during World War II. The second case applies the model to the crews involved in the misidentification and shootdown of two U.S. Army UH-60 Black Hawk helicopters by two U.S. Air Force F-15C fighter jets following the first Gulf War.

B. THE CASES ON BOTH SIDES OF THE SPECTRUMS

The German military's failure to uncover the Allied deception masking the invasion of Normandy and the shootdown of two friendly UH-60 Black Hawk helicopters by two U.S. Air Force F-15C Eagle jet fighters in Northern Iraq are two cases that provide varied frameworks on which to apply the command DMSC. In both cases, information gaps lead to catastrophic events, from the subject's point of view. These two cases each have multiple examples that can be used to attempt validation of the model across the multiple spectrums of the described criteria.

During World War II, the prevalent technology used for German intelligence collection included radio transmitters and receivers, primitive radar devices, and aerial photography while data were disseminated between analysts, advisors, and commanders by means of telephone, teletype, and written reports (U.S. War Department, 1984). Following the first Gulf War, the prevalent technology used by the U.S. Army and U.S. Air Force included sophisticated airborne radar, electronic identify friend or foe (IFF) transponders, and jamming-resistant radio transmitters and receivers. Data were disseminated from collection platforms to ground-based watch stations via advanced data links (Snook, 2000). The applicability of the command DMSC in both situations will demonstrate its timelessness and ability to survive advances in the technology that collects, processes, and transfers information.

German efforts to determine the location of the planned Allied invasion of Northern Europe was a strategic operation that used national assets. The friendly Black Hawk shootdown occurred during a routine tactical mission, a scan of the no-fly zone (NFZ) in northern Iraq prior to daily operations (Snook, 2000). The decision makers in the two situations range from a sovereign nation's dictator to simply a pilot in charge of two aircraft. The command DMSC should apply to both, indicating it can be used in situations at any level of war.

Another difference between the two situations is the amount of time required for the events to unfold and information to ascend the model. The German high command collected and processed information regarding the potential Allied invasion site for months.

Conversely, less than ten minutes elapsed from the F-15Cs' initial detection of the friendly Black Hawk helicopters to their shootdown (Snook, 2000). The applicability of the DMSC in identifying sources of information gaps in both situations will prove its utility in situations with varying tempo.

The rigid structure of the German high command and subordinate units contrasts greatly with ambiguous command relationships present between the airborne crews in the NFZ in northern Iraq. By applying the command DMSC to both, one will see its utility across the whole spectrum of command relationships that military decision makers operate in. Command relationships may include those with direct subordinates, peer units, and even third-party organizations that operate in the same environment.

C. APPROACH TO ANALYSIS

What follows in Chapter IV are not exhaustive case studies of the German Intelligence's response to Allied deception efforts and the F-15C pilots' actions. For in-depth case studies reference Brown's (1975) *Bodyguard of Lies* and Snook's (2000) *Friendly Fire*. Instead examples from these two historical cases are used as tools to test the command DMSC.

This thesis focuses on investigating how specific pieces of data that existed in the world and could have prevented the catastrophes (i.e., specific shapes in oval 1) failed to ascend to the decision maker in time to inform the critical decision. The ability to attribute in both cases the cause of the data's failure to ascend the model to the sources of information gaps identified in Chapter II, Section F will demonstrate the model's utility. Note that this analysis will focus on very specific aspects of the cases. The intent is to demonstrate how one of the four sources of information gaps identified in Chapter II, Section F is present in each example. Thus, while the investigation may indicate the presence of multiple sources of information gaps, for example uncertainty and complexity may have led to both a failure to collect and failure to correctly filter, the single most prominent source of the information gap will be identified and analyzed.

Chapter IV will contain a brief synopsis of the pertinent details of each example in both cases. The actors will be placed in the command DMSC framework with only the

individuals relevant to the information gaps depicted. Then the flow of pertinent data will be traced from oval 1 to the place in the model where the data stagnated. The root cause of the stagnation will be identified and analyzed to see if it can be characterized as one of the sources of information gaps identified in Chapter II, Section F.

IV. ANALYSIS

A. NORMANDY

Numerous elements of data indicating the time and location of the Allied invasion failed to ascend the German military's command structure. Starting at oval 1, the data contained in weather observations, imagery from the Luftwaffe, and wireless intercepts will be traced through a command DMSC constructed for each example. The analysis is not a study of the Allied deception efforts effectiveness, but a determination of what contributed to the information gaps that existed in the German decision makers' comprehension and projection ovals.

1. Uncertainty-Rooted Information Gap: A Lack of Weather Sensors

a. Situation

The German failure to detect the improvement in weather conditions that allowed the Allied invasion to proceed demonstrates an uncertainty-based information gap. The lack of sensors in the correct position to report the changing weather conditions left critical data from oval 1, a break in the stormy weather, uncollected and unable to propagate to the German decision makers (Breuer, 1993). This uncertainty-based information gap influenced multiple German commanders' actions leaving their forces unprepared the night before the invasion (Breuer, 1993).

b. Events

Allied planners selected a three-day window for the Normandy invasion, starting on June 5, during which beach obstacles and landing points would be illuminated by a full moon and visible because of low tides; however, as the date approached, Allied and German forecasters alike predicted adverse weather conditions that would prevent any cross-channel invasion during the time period (Klein, 2014). The storms rolled in as predicted, forcing a 24-hour postponement of the invasion to June 6; but shortly after the postponement, Allied weather stations in Western Ireland detected changing conditions indicating a lull in the storm that would allow for the cross-channel invasion to proceed on

the new timeline (Klein, 2014). Overseeing a network of weather stations and sensors inferior to the Allies, the head German meteorologist for the West, Colonel Walther Stroebe, issued forecasts made from limited data (Breuer, 1993). Breuer notes that “Stroebe had no far-reaching network of weather stations, well-equipped weather ships, or aircraft far out into the Atlantic” (p. 191). German sensors were unable to collect adequate data as Ross (2014) points out: “[t]he flow of meteorological data from Wekusta units [Luftwaffe meteorological units] faded with increasing Allied dominance of skies over western Europe” (pp. 151–152). Stroebe, unaware of the approaching break in the storm because of a lack of sensors, maintained his forecast that weather would prohibit any channel crossing or amphibious landing in Northern France (Latimer, 2001). The disparity between Allied and German weather sensor coverage was consequential. Brown (1975) notes the impact of achieving weather sensor superiority over the German forces in his claim “Allied victories in the little heralded weather war had systematically deprived the Germans of the means to forecast such subtle changes. It was for this moment alone that the weather war had been fought” (p. 639). Stroebe’s inaccurate forecast ascended to German commanders with unfortunate effects. Field Marshal Erwin Rommel, in charge of German forces on the northern coast of France, was so confident in the unfavorable forecast that he took leave during the entire invasion window (Ross, 2014; Latimer, 2001). Rear Admiral Walther Hennecke, in charge of German naval forces stationed in Normandy, was so confident that the adverse weather would continue that on the eve of the invasion he disregarded radar reports of abnormally heavy traffic in the English Channel and canceled the regular E-boat patrols (Breuer, 1993).

c. Analysis

An uncertainty-based information gap, described in Chapter II, Section F1, as a failure of data to ascend from oval 1 to oval 2, influenced both commanders’ decisions. Figure 8 illustrates the uncertainty-based information gap caused by the deficiency of German weather sensors and stations. Each hourglass symbol represents the individual DMSC of each member of the command. When placing this example in the command DMSC framework, Stroebe serves as a principal advisor to two separate commanders, Rommel and Hennecke, and maintains his staff of weather specialists subordinate to him.

Atmospheric conditions indicating a break in the storm existed in oval 1 in Western Ireland and the Atlantic Ocean but were not detected by Strobe's weather specialists because there were no German weather sensors in the area (Klein, 2014; Breuer, 1993). Thus, the data were not present in any of the weather specialist's oval 2 and were unable to ascend to Strobe's oval 5 or 6 causing him to change his forecast to indicate a break in weather. The forecast Stroebe made and that Rommel and Hennecke based their decisions on was influenced by the information gap present in the weather specialists' oval 2.

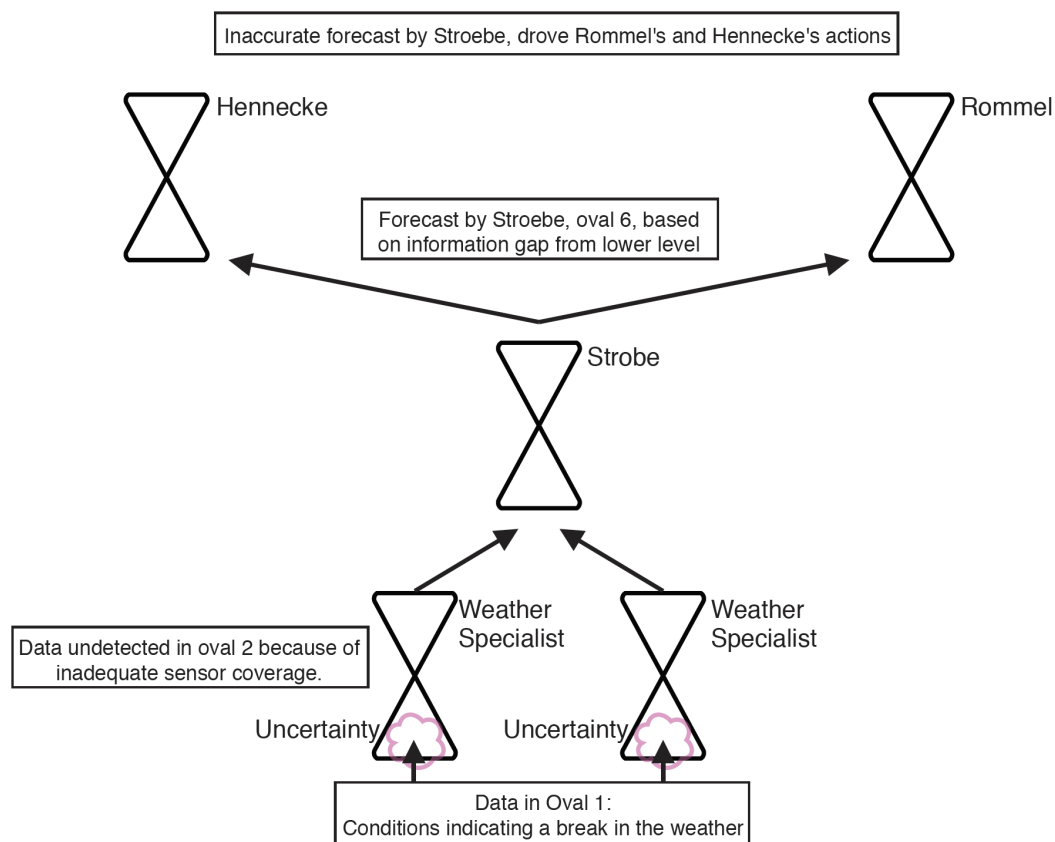


Figure derived from sources outlined in Chapter IV, Section A1.

Figure 8. Uncertainty in Normandy

2. Complexity-Rooted Information Gap: Colonel Roenne's Wavering between Normandy or Calais

a. Situation

The selection of Pas de Calais instead of Normandy as the anticipated location of the main Allied invasion site by Colonel Alexis von Roenne, the head of intelligence for the *Fremede Heere West* (FHW), illustrates a complexity-based information gap (Latimer, 2001). Inundated with multiple sources and forms of intelligence, Roenne incorrectly filtered data from oval 3 and misinterpreted data in oval 4, resulting in an information gap: Allied forces were staging for an invasion of Normandy (Latimer, 2001). This information gap resulted in inaccurate comprehensions and projections by Roenne that ascended to Hitler.

b. Events

In the months preceding D-Day, Roenne was the officer responsible for assimilating all intelligence reports and predicting Allied actions; as Breuer (1993) explains, "it was his mission to provide the fuehrer [*sic*] with the definitive hard intelligence he needed to make troop deployments.... His incredibly complicated and frustrating task was to produce a *Feindbild*, or picture of the enemy, including the Anglo-American order of battle for the pending invasion" (p. 39). Hitler's confidence in the accuracy of Roenne's intelligence was unquestioned because Roenne had accurately predicted the Western response to Germany's invasion of Poland (Breuer, 1993). Though the content of Roenne's reports was satisfactory, their timeliness was not. In January of 1944, Hitler's chief of staff placed renewed pressure on Roenne to determine the location of the impending Allied invasion (Farago, 1971). Roenne, aided by intercepted messages from signals intelligence (SIGINT), captured documents from HUMINT, and a personnel inspection of the weak state of German defenses in France, settled on the Northern coast of France (Farago, 1971). Roenne's prediction was in line with Allied planners who had initially determined that Normandy or Pas de Calais were the only feasible invasion locations due to their short distance from England, enabling rapid turnaround of landing craft and supply vessels and short range from airfields enabling air cover for invasion

forces (Van Creveld, 1977). By the end of January 1944, Roenne set his sights on Calais (Farago, 1971). Though SIGINT and HUMINT reports of troop buildup in southern England, most of which were Allied deception efforts, did indicate the invasion was bound for the northern coast of France, “none of the incoming reports had referred to any massive concentration of troops and equipment, or even any unusual activity, behind the white cliffs of Dover [which lie across the channel from Pas de Calais]” (Farago, 1971, p. 606).

As HUMINT reports of a formidable army being staged across the English Channel from Pas de Calais, all fictitiously generated by Allied deceptionists, flowed in over the next few months for Roenne’s analysis, German airborne reconnaissance spotted a massing of forces in the southwest of England pointing to an invasion at Normandy (Latimer, 2001). Based on the Luftwaffe reconnaissance, Roenne issued an intelligence report indicating Allied forces were staging in the southwest in preparation for a Normandy invasion; however, days later, influenced by additional HUMINT reports of activity in the southeast and a surge of Allied aircraft operating to the southeast, Roenne reverted to his original prediction of Pas de Calais as the landing site (Latimer, 2001).

c. Analysis

The intelligence necessary to determine that the Allies were staging for Normandy was present in Roenne’s oval 3. Also present in his oval 3 was intelligence indicating the Allies were staging for Pas de Calais. Roenne experienced Zack’s (1999) definition of complexity: “having to process more information that you can manage or understand” (p. 354). To cope, he conducted expectation filtering, described in Chapter II, Section F2, and ignored some of the data leading to its failure to ascend from oval 3 to oval 4. This created a complexity-based information gap that Figure 9 illustrates. Here Roenne serves as a principal advisor to Hitler and oversees multiple intelligence specialists from varying disciplines, HUMINT, imagery intelligence (IMINT), and SIGINT. An accurate HUMINT report named Normandy as the primary invasion site and reported correctly a month-long window that the Allies were planning the assault, but the reports were disregarded because the “information simply differed from the preconceived notions of Hitler and his aides, and from the basic conclusion of Colonel von Roenne” (Farago, 1971, p. 616). This is a

demonstration of Coakley's (1992) claim that the unexpected is often ignored in favor of the expected.

Another complexity-based information gap developed due to Roenne's disproportionate reliance on a single type of intelligence, HUMINT, over IMINT from the Luftwaffe reconnaissance or SIGINT from intercepted messages. Shattuck and Miller's (2006) assertion that individuals cling to a particular type of data because it has served them in the past and Pfeffer and Salancik's (2003) claim that challenging-to-obtain data are left uncollected in favor of easily obtained data are both visible in this example. Roenne was highly confident in HUMINT because it had previously confirmed SIGINT that pointed to the cross-channel invasion as the main Allied assault (Breuer, 2001). Additionally, SIGINT and IMINT were not as readily available as HUMINT to Roenne; as Delmer (1971) notes, "the efficiency of the German radio interception services [SIGINT] had declined since" the early days of the war (p. 154). He continues that the "the reconnaissance flights of the Luftwaffe were so few and far between that—as the Foreign Armies West never ceased complaining—the intelligence produced by them was lamentably incomplete and unreliable when they did report" (Delmer, 1971, p. 154). Consequently, Roenne built his *Feindbild* primarily from HUMINT (Delmer, 1971). Bias from past experience in Roenne's lens B caused him to prioritize HUMINT reports in oval 4 pointing to Pas de Calais over IMINT reports in oval 4 indicating Normandy. HUMINT reports of the growing strength of the fabricated First U.S. Army Group (FUSAG) across the channel from Pas de Calais trumped IMINT from Luftwaffe reconnaissance flights that depicted the Allied fleet that would transport the invasion force across the channel in the vicinity of Portland across from Normandy (Latimer, 2001; Delmer, 1971). Thus, the complexity-based information gaps created in Roenne's ovals 3 and 4 from expectation filtering and bias in his lens B propagated up to Hitler and influenced his decisions regarding troop movements.

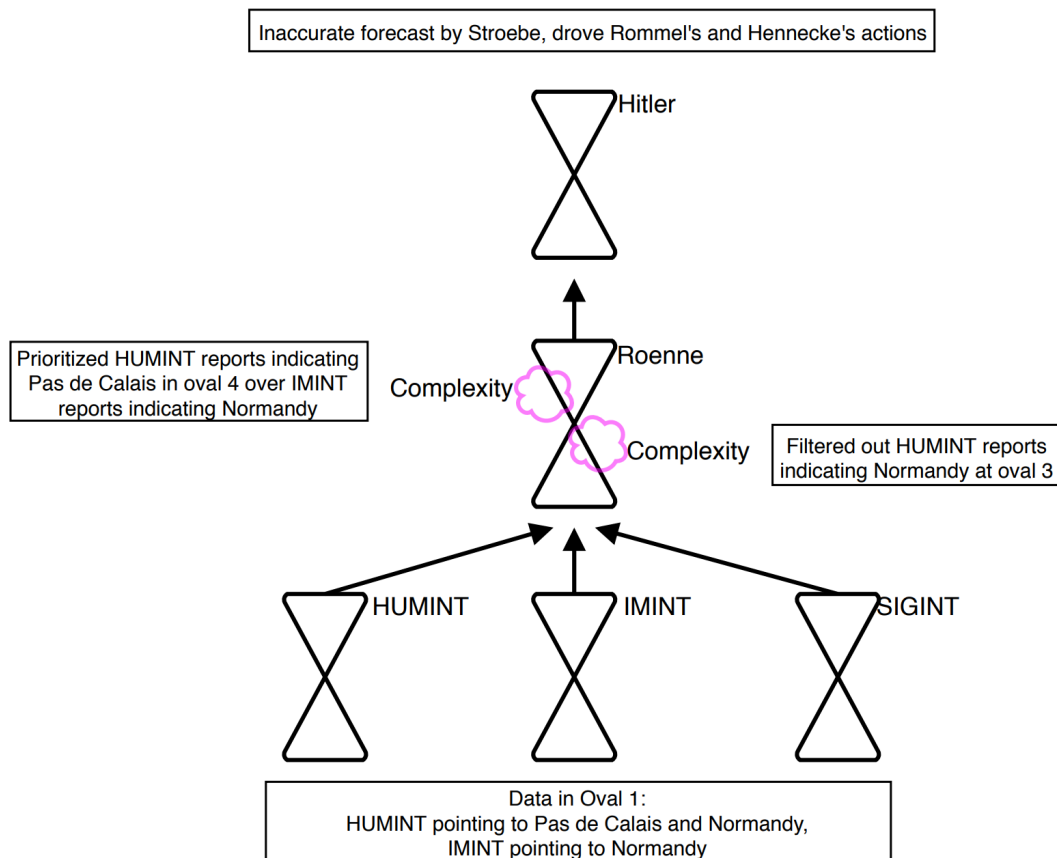


Figure derived from sources outlined in Chapter IV, Section A2.

Figure 9. Complexity in Normandy

3. Ambiguity and Uncertainty-Rooted Information Gaps: Inflated Estimates

a. Situation

The modification by Walther Schellenberg's *Sicherheitsdienst* (SD), a *Schutzstaffel* (SS) foreign intelligence organization, of Roenne's estimates of the Allied strength in England prior to forwarding them to Hitler demonstrates an ambiguity-based information gap (Breuer, 1993). Roenne's doubling of the estimates in response illustrates how unchecked feedback loops in the command DMSC can create mis-calibrated sensors further resulting in uncertainty-based information gaps (Breuer, 1993). The combination

of these two information gaps ascended to Hitler's oval 5 and contributed to his delay in sending reinforcements to Normandy after the invasion (Delmer, 1971).

b. Events

Despite Hitler's trust in Roenne's abilities and reporting, the organizational structure of German intelligence "required that all FHW [*Fremede Heere West*] reports be filtered through the SD in order to 'ensure their accuracy' and to be certain that they corresponded with the information and evaluation of the SD" (Brown, 1975, p. 497). As Schellenberg's SD received and analyzed Roenne's reports though, it routinely halved the estimates of Allied strength before pushing them to Hitler (Breuer, 1993). Believing the SD was superior to all other intelligence agencies, Schellenberg reported to Hitler primarily news that was favorable and aligned with Hitler's view (Owen, 1978). Schellenberg accomplished this by altering Roenne's reports. When Roenne found out that his Allied strength reports were being halved and that Hitler was pulling forces from the West to bolster the Russian front based on these weakened Allied strength reports, he began doubling them (Breuer, 1993). Roenne released a report containing doubled Allied strength, but interestingly the SD did not alter it before forwarding it to Hitler (Breuer, 1993). Upon reaching Hitler, this greatly exaggerated report gave credibility to the fictitious FUSAG leading him to believe that to Allied forces staged in England were great enough to execute multiple diversionary attacks and a main invasion at Pas de Calais (Delmer, 1971). The effect these information gaps had on Hitler was so great that they enabled his decision to not send reinforcements from the 15th Army in place at Pas de Calais to meet Allied forces at Normandy for seven weeks because he anticipated a main invasion to follow there (Delmer, 1971).

c. Analysis

Figure 10 illustrates this information gap using the command DMSC framework and establishes Schellenberg under Hitler as a principal advisor and Roenne under Schellenberg as a technical specialist. Chapter II, Section F3 explains that ambiguity occurs when data fails to ascend correctly from oval 4 to 5 because of expectations or deficiencies in lens B that are not mitigated through knowledge transfer. Schellenberg received

Roenne's FHW estimates in his oval 4, but his lens B caused him to alter oval 4's contents to fit Hitler's and his own shared point of view. Using Coakley's (1992) terminology, Schellenberg reshaped the data in oval 4, estimates of Allied strength from Roenne, when placing it in oval 5 to fit expectations. The flow of data from Roenne to Schellenberg was one way, and no dialogue that could potentially resolve the discrepancy between the lenses of the two intelligence officers occurred prior to their modification (Johnson, 2001). Johnson (2001) notes "there was nothing he [Roenne] could do about it. The SD was a party organization, and could do pretty much what it wanted" (p. 80). Knowledge transfer from Roenne to Schellenberg that would have augmented Schellenberg's lens B and provided him the implicit knowledge to process the reports in oval 4 correctly did not occur. It did not occur because many of the barriers to knowledge transfer identified by Davenport and Prusak (1998) inhibited it.

The most apparent of Davenport and Prusak's (1998) barriers to knowledge transfer was that in Hitler's military "status and rewards go [or went] to knowledge owners" (p. 97). Schellenberg was ambitious and "hungered to be the hero who could go to the fuhrer and tell him the true secrets of the Allies' D-Day, an intelligence bonanza that could skyrocket Schellenberg into a post as head of all intelligences agencies" (Breuer, 1993, p. 18). This ambition and hunger for control is what drove Schellenberg to review all intelligence gathered by non-Nazi party entities, such as Roenne's FHW, in the first place (Johnson, 2001).

Additionally evident in the command culture shaping the interaction between Roenne and Schellenberg were Davenport and Prusak's (1998) barriers of "lack of trust" and "different...frames of reference" (p. 97). The competing goals of Roenne and Schellenberg lead to mistrust and lenses that processed data differently. Roenne's concern that the German forces in the west were ill-prepared for the mounting Allied threat in England and motivation to create an accurate picture of that threat, even if it opposed Hitler's views, shaped his lenses (Delmer, 1971). Meanwhile, Schellenberg's personal ambitions and concern for concealing his own organization's intelligence failures shaped his lenses (Owen, 1978). The last barrier present between Roenne and Schellenberg was the "lack of absorptive capacity in recipients" (Davenport and Prusak, 1998, p. 97). The

same factors shaping Schellenberg's lenses made him unwilling to listen and evaluate any conflicting reports. One can see in Schellenberg's actions that he was focused on that which would increase his importance to the decision maker, a theme presented by Pfeffer and Salancik (2003). Thus, ambiguity-based information gaps caused by a failure of vertical knowledge transfer between Schellenberg and Roenne and uncertainty-based information gaps caused by unchecked feedback loops affected Hitler's oval 5.

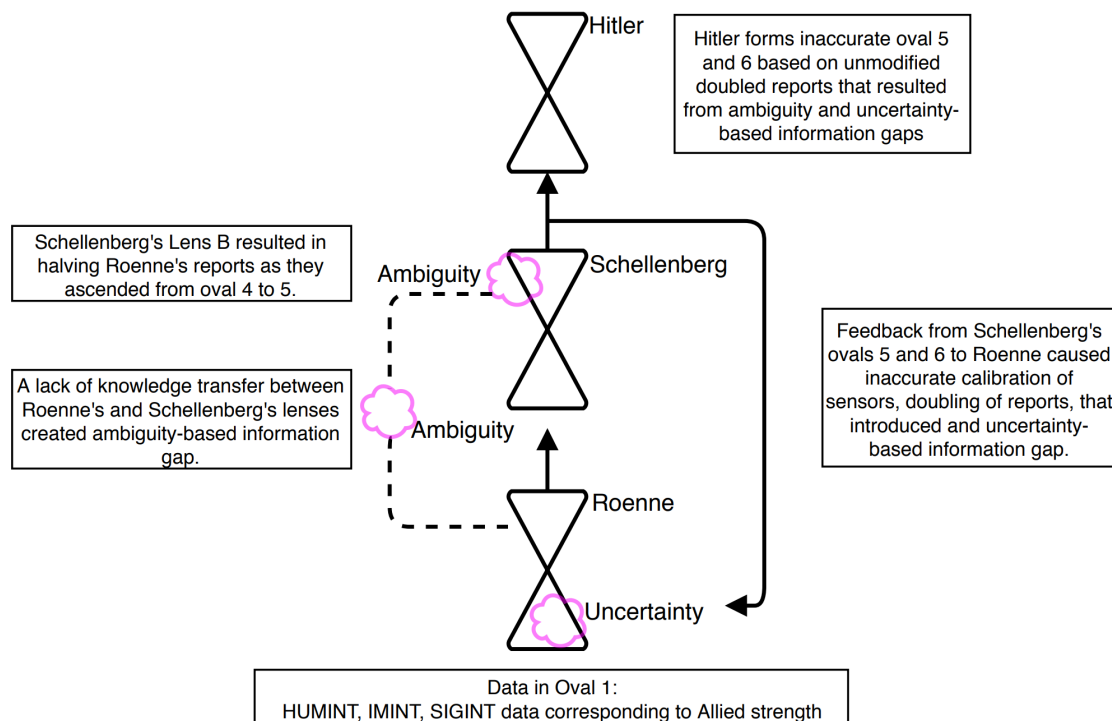


Figure derived from sources outlined in Chapter IV, Section A3.

Figure 10. Ambiguity and Uncertainty in Normandy

4. Equivocality-Rooted information Gaps: Interpretations of Luftwaffe Imagery

a. Situation

The differing interpretation of Luftwaffe reconnaissance reports over Allied forces in southern England by Field Marshals Erwin Rommel and Gerd von Rundstedt demonstrates an equivocality-based information gap. Presented with the same report or

data to make sense of in oval 4, both Field Marshalls interpreted in oval 5 the data differently, resulting in contradictory projections in oval 6 that ascended to Hitler for resolution (Breuer, 1993).

b. Events

Rommel commanded *Heeresgruppe* [Army Group] B, which consisted of the Fifteenth Army in Pas de Calais and the Seventh Army in Normandy, while Rundstedt commanded *Heeresgruppe* G, which consisted of the First and Nineteenth Armies in central France (Latimer, 2001). Despite the massive number of forces underneath each Field Marshal's command, Hitler maintained control of all major troop movements and the deployment of Panzer divisions currently held in reserve (Breuer, 1993; Latimer, 2001). The two field marshals differed in their anticipation of the Allied invasion sites. Rommel believed the Allies were destined for Normandy because German fortifications there were less formidable than at Pas de Calais (Perrault, 1965). Conversely, Von Rundstedt anticipated the Allied invasion to come at Pas de Calais because it was the shortest cross channel crossing, it provided the most direct route to the heart of Germany, and it would allow destruction of the V-weapons based there, which were capable of wrecking destruction on England (Latimer, 2001; Hart, 1999).

Despite the Allied air power's superiority, Luftwaffe reconnaissance was capable of producing some intelligence of value. Rundstedt's chief of staff recalled that "[t]owards D-day, however, night-flying 'planes [*sic*] reported large movements of transport towards the south-west coast-which they could follow because the vehicles had their headlights on" (Hart, 1999, p. 391). In their separate headquarters, Rommel and Rundstedt reviewed the reports and drew different conclusions (Breuer, 1993).

c. Analysis

Equivocality-rooted information gaps are created by the inability to reconcile multiple individuals' competing comprehensions and projections and slow processing of the next superior in the model. Figure 11 illustrates the development of this information gap and places Rommel and Rundstedt as principal advisors to Hitler. Underneath them, is the same Luftwaffe intelligence processing organization that provided reports from

reconnaissance flights. As Rundstedt studied the reports present in his oval 4, his lens B, shaped by the anticipation of an invasion of at Pas de Calais, interpreted them as “an Allied ploy to convince him that the landings would come in Normandy rather than the Pas de Calais” (Breuer, 1993, p. 184). Rommel’s lens B, shaped by the belief that the invasion was coming at Normandy, focused on different points of data from the reports to confirm his expectations. Instead of focusing on what was present in the reports (e.g., transport vehicle movement during night hours around Normandy), he noted the lack of imagery collected of the southern ports (Breuer, 1993). Breuer explains, “Rommel noted that daylight reconnaissance planes were allowed to fly over southeastern England (in the FUSAG region) without heavy opposition from the RAF [Royal Air Force], but when German aircraft tried to reach the Channel ports in southern and southwestern England, they were driven off by swarms of British fighter planes before they could take pictures” (p. 185). Differing lenses between the two principal advisors resulted in diverging comprehensions of Rommel and Rundstedt in their oval 5s that ascended to Hitler. This equivocality-based information gap had to be resolved by Hitler prior to any decisions regarding troop movements.

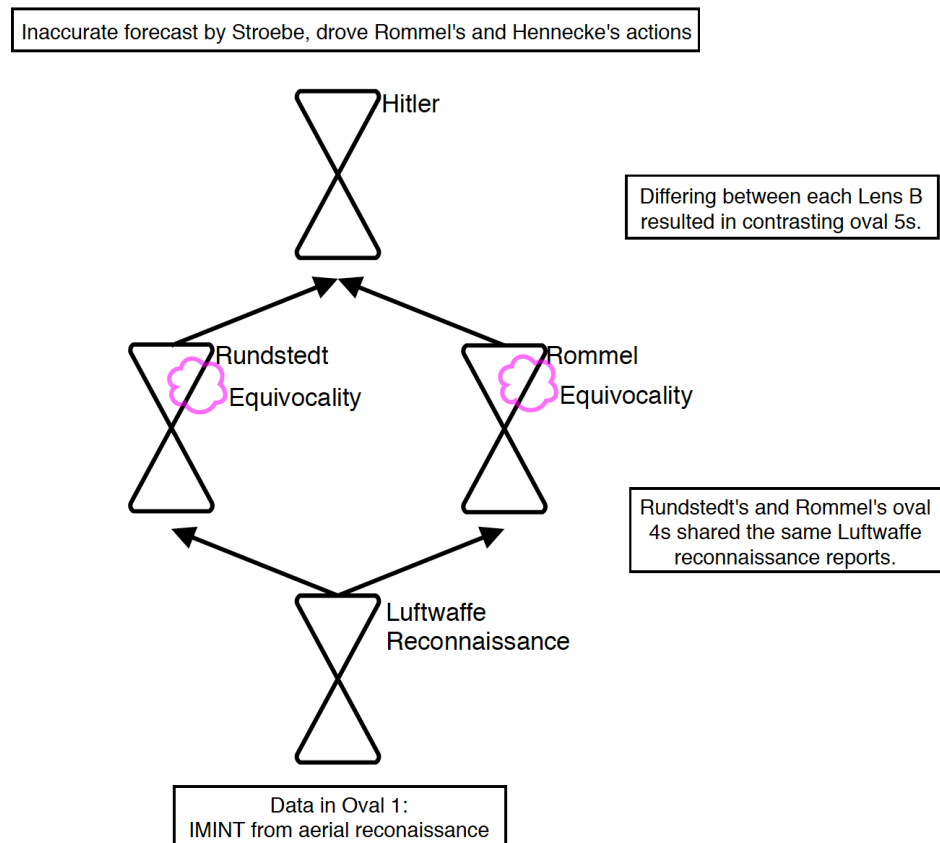


Figure derived from sources outlined in Chapter IV, Section A4.

Figure 11. Equivocality in Normandy

B. IRAQ

The shootdown of two U.S. Army UH-60 Black Hawk helicopters by two U.S. Air Force F-15C Eagles, under the surveillance of an E-3B Airborne Warning and Control System (AWACS) crew, during Operation Provide Comfort (OPC) in the NFZ of Northern Iraq demonstrates the creation and propagation of information gaps through a military organization (*Friendly Fire Shootdown*, 1995). The purpose of this analysis is not to debate the root causes of the accident found by the investigation board or authors who have researched the subject or to extrapolate useful learning points from the tragic event. The purpose is to identify the formation of information gaps using the command DMSC

framework. Determining key pieces of information that, if present at the correct place in the command DMSC, may have prevented the shootdown and identifying the cause of their failure to reach that place in the command DMSC (i.e., the source of each information gap) will accomplish this.

The presence inside oval 5 of the lead F-15C pilot, Tiger 01, of any one of the following three pieces of information could have prevented the shootdown of the UH-60s: the fact that there were friendly helicopters operating inside the tactical area of responsibility (TAOR), the UH-60's IFF transponder Mode I and Mode IV squawks, and the visual distinguishing features that identify a U.S. Army UH-60 (e.g., the painted American flags or the side-by-side cockpit) (Snook, 2000). Each of these pieces of data were present in oval 1; however, they all failed to ascend to Tiger 01's comprehension of the environment, oval 5, or projection of its future state, oval 6.

1. Arrangement of Crews in Command DMSC

The placement of the AWACS crew, the F-15C pilots, and the UH-60 pilots in the command DMSC is complicated by the irregular command relationships between them, their physical distance from a single unifying commander, and the number of layers between each crew and that single unifying commander. The UH-60 pilots were based out of Pirinlick Air Base, Turkey while the AWACS crew and F-15C pilots were based over 250 miles away out of Incirlik Air Base, Turkey (Snook, 2000). Leveson (2012) notes, “[t]he helicopters and fixed wing aircraft had separate control structures that only joined fairly high up on the hierarchy and...there were communication problems between the components at the higher levels of the control hierarchy” (p. 154). While all the crews fell under a single combined task force (CTF) commander, each of the crews had an unclear and contrasting understanding of the command relationships that was created in part by the different geographic locations of the units, the multiple service components comprising the task force, and the frequent rotation of personnel to the theater (Snook, 2000). Snook notes a member of the CTF staff's description of “just how contentious and confusing these multiple crosscutting lines of authority had become” (p. 131). The CTF staffer reported that “*there were no real clear lines of authority or responsibility in this situation. ... [T]he*

aircraft operated out there pretty much on their own” (Snook, 2000, p. 131). Because of the absence of single commander making decisions and issuing commands inside the TOAR on 14 April 1994, Tiger 01 will be the central focus of the command DMSC analyzed for information gaps. He ultimately made the decision to shootdown the UH-60s, therefore the flow of data and information from all the models to his ovals 5 and 6 are of most importance. Figure 12 depicts Tiger 02, his wingman, placed subordinate to him. The lead UH-60 pilot, Eagle 01, is placed to his side as a peer. The pilot of the second UH-60, Eagle 02, is placed subordinate to Eagle 01. Also adjacent to Tiger 01 is the AWACS’s Mission Crew Commander. The AWACS’s mission crew consisted of 15 members, was arranged in three sections, and was overseen by the Mission Crew Commander (Snook, 2000). The crewmembers pertinent to the analysis for information gaps follow. The enroute controller, “responsible for controlling the flow of OPC aircraft to and from the [TAOR],” and the TAOR controller, “responsible for threat warning and tactical control for all OPC aircraft within the TAOR,” reported to the Senior Director, who reported to the Mission Crew Commander (Snook, 2000, p. 43). The Airborne Command Element (ACE) also onboard provided “an immediate line of command to the CFACC [combined force air component commander] through the Mission Director on the ground]” (Snook, 2000, p. 43). The ACE is also placed adjacent to the AWACS crew, Tiger 01, and Eagle 01 in the command DMSC. The cross-functional area and cross-hierarchical levels communication between crews differentiate this scenario from the rigid German command structure in the Normandy example. The communication of the lead aircraft pilots, Tiger 01 in the F-15C and Eagle 01 in the UH-60, with TAOR and enroute controllers respectively was lateral and vertical (Snook, 2000).

2. Analysis for Gaps

Tracking each of the three pieces of data from their existence in oval 1 to the point in the model where they fail to ascend to the next oval and investigating the cause to their failure to ascend will identify the source of the information gap as either uncertainty, complexity, ambiguity, or equivocality. Analysis may reveal a piece of data’s failure to ascend is the result of multiple causes, for example complexity and ambiguity. However, to simplify the process and test the command DMSC’s effectiveness at identifying each of

the sources of information gaps introduced in Chapter II, Section F, the investigation of each piece of data's failure to ascend will primarily focus on identifying the contributions of a single cause.

a. *Ambiguity-Rooted Information Gap: The Presence of Friendly Helicopters in the TAOR*

At the time of Tiger 01's check-in with the AWACS enroute controller, Eagle Flight was already inside the TAOR and headed deep beyond its border toward Irbil (*Friendly Fire Shootdown*, 1995). This section's focal piece of data existing in oval 1 is Eagle Flight's presence inside the TOAR border and its direction of flight further into the TAOR. This piece of data was detected in oval 2 by the enroute controller's sensors when he heard Eagle 01's ultrahigh frequency radio transmission "COUGAR, EAGLE 01 is enroute WHISKEY to LIMA" (Snook, 2000, p. 55). The enroute controller's acknowledgment of the radio call shows the data ascended up to his oval 4, but a lack of the implicit knowledge in his lens B prohibited its ascension to oval 5, comprehension. The enroute controller did not know the location of LIMA, did not look in the onboard reference that linked code words with city names, and did not ask Eagle 01, his supervisor, or a fellow controller for clarification of LIMA's location to build the contents of his lens B (Snook, 2000). Because he did not have the framework to understand the data, the helicopters' destination far inside the TAOR, the information failed to ascend to oval 5 and was unavailable to transfer to Tiger 01's oval 3. The en route controller's supervisor, the Senior Director, was also aware of Eagle Flight's destination of LIMA according to his testimony after the event (*Friendly Fire Shootdown*, 1995). While it is not explicitly stated in the reports available that he was monitoring the en route controller's frequency at the time the code words for the route of flight were transmitted, the Senior Director did monitor the radio communications between his controllers and the aircraft they were controlling to fulfill his supervisory duties. Therefore, he likely knew Eagle's destination was LIMA because he heard the radio transmission, not because the en route controller reported it to him.

A complete nonuse of code words and lack of understanding of all OPC helicopter missions by AWACS crewmembers provides further evidence that the lens of the en route

controller and the Senior Director was deficient and therefore unable to make sense of the perceived data in oval 4. Leveson (2012) notes that both the CFACC staff, the Mission Director and the ACE, as well as the AWACS crews held “that helicopter activities were not an integral part of OPC air operations” and that the AWACS controllers did not believe they proceeded past the border town of Zakhu (p. 141). Levenson continues “the Delta point system (wherein the helicopter crews provided the AWACS controllers with their flight plan [in code words]) was not used by the AWACS controllers: When the helicopters went beyond Zakhu, the AWACS controllers did not know their flight plans and therefore could not relay that information to the fighter pilots and other OPC participants” (p. 158). Thus, when the constant feed of the helicopters position was unavailable because radar coverage was lost, the enroute controller did not have the implicit knowledge in his lens B to make sense of the contents of oval 4, Eagle Flight was enroute to LIMA. This piece of information dropped out because it was not understood and was therefore never comprehended in the en route controller’s or Senior Director’s oval 5 or passed laterally to Tiger 01’s oval 3.

To make sense of oval 4’s contents requires merging of explicit information with the implicit knowledge in lens B. When the contents of lens B is insufficient and is not augmented by knowledge transfer, an ambiguity-rooted information gap develops. Both the en route controller and the Senior Director did not possess the requisite implicit knowledge in their lens B to make sense of the code word LIMA and they failed to build their lens B through knowledge transfer. The result was an ambiguity-rooted information gap that propagated to Tiger 01 as illustrated in Figure 12.

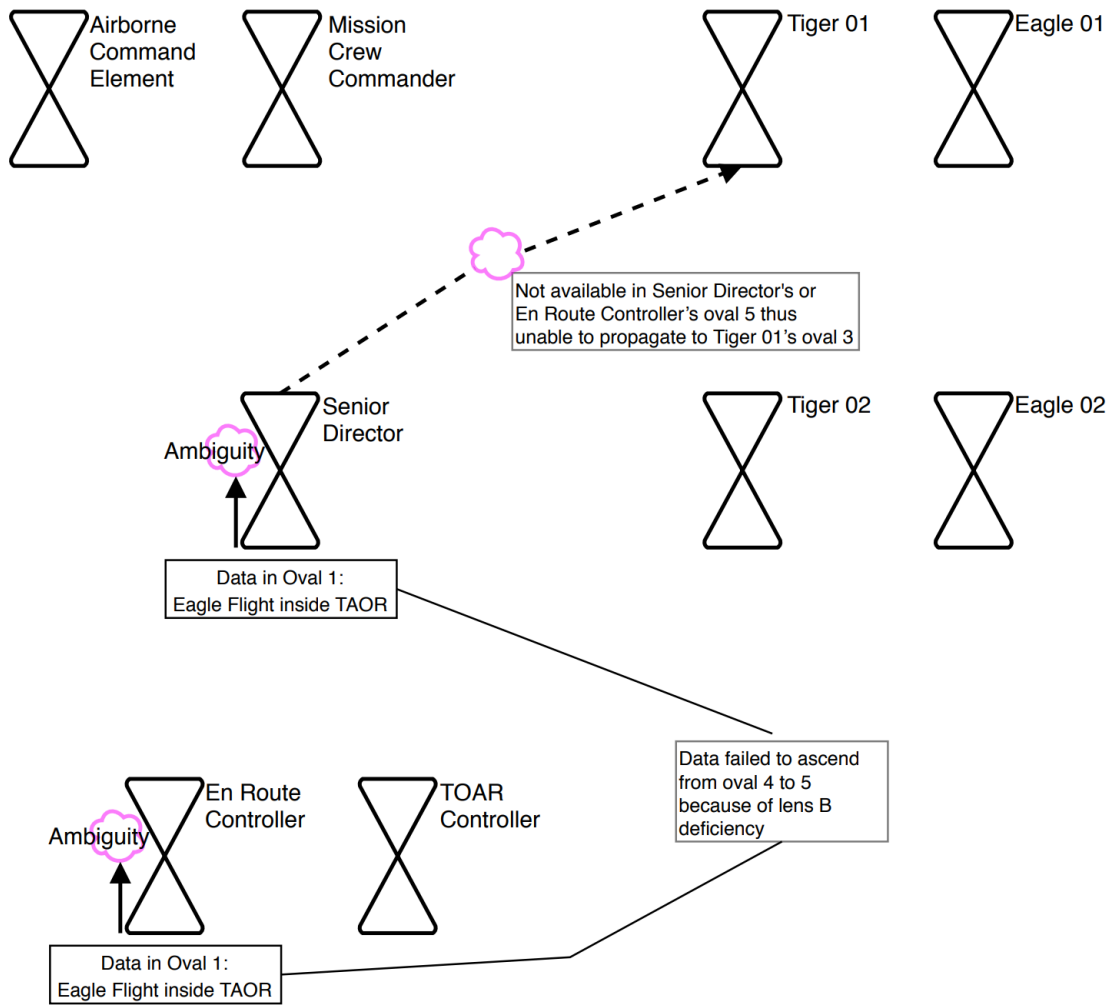


Figure derived from sources outlined in Chapter IV, Section B2a.

Figure 12. Ambiguity in Iraq

b. Uncertainty-Rooted Information Gap: Eagle Flights IFF Squawk

The lack of detection of Eagle Flight's Mode I and Mode IV IFF squawks by Tiger 01 and Tiger 02's sensors demonstrates an uncertainty-based information gap that contributed to the shootdown. This section's focal pieces of data are Eagle 01 and Eagle 02's Mode I and Mode IV IFF squawks. Eagle Flight maintained Mode I IFF code 42, the code listed for helicopter use on the air tasking order (ATO) they received, throughout the duration of the flight (Leveson, Allen, & Storey, n.d.; Snook, 2000). After detecting radar contacts 40 nautical

miles southeast of their position inside the TAOR, Tiger 01 used his IFF interrogator to query the radar contact's IFF (Snook, 2000). However, Tiger 01 set his IFF interrogator to look for Mode I code 52, the code specified on his copy of the ATO for use by OPC aircraft inside the TAOR (Snook, 2000). Because Eagle Flight's Mode I code was set to 42, Tiger 01 received no response that the contact was squawking a friendly IFF code (Snook, 2000).³ Tiger 01's sensor, his IFF interrogator, was misdirected, set to look for code 52, while oval 1 contained Eagle Flight squawking a different code, code 42. Thus, an uncertainty-based information gap originated: Tiger 01 did not detect the friendly yet inaccurate according to Tiger 01's ATO Mode I IFF response from Eagle Flight.

Snook (2000) reports that upon not receiving a Mode I response, Tiger 01 interrogated the radar contact's Mode IV code and received a one-second friendly response. Then without any input to the system, Tiger 01's IFF interrogator reported the contact was not squawking any IFF Mode IV (Snook, 2000). As the situation developed, Tiger 01 interrogated the radar contact's Mode I and Mode IV multiple times, including immediately prior to firing the fatal missile, and received no response (Snook, 2000). Reports indicate that Tiger 02 also interrogated the Mode IV of the contacts and also did not receive a response (*Friendly Fire Shootdown*, 1995). Though the number of IFF Mode I and Mode IV interrogations Tiger 01 executed varies based discrepancies between Tiger 01's statements, the actual number is not relevant to this analysis for the creation of information gaps (U.S. Government Accountability Office, 1997). Leveson (2012) quotes the investigation report that found "[t]he reason for the unsuccessful Mode IV interrogation attempts cannot be established, but was probably attributable to one or more of the following factors: incorrect selection of interrogation modes, faulty air-to-air interrogators, incorrectly loaded IFF transponder codes, garbling of electronic responses, and intermittent loss of line-of-sight radar contact" (pp. 123–124). Two senior commanders in the helicopter's chain of command disagreed that the helicopter's Mode IV IFF codes were incorrectly loaded, stating that nothing in the investigation report suggested

³ Two years before the shootdown, the ATO assignment of Mode I codes for OPC aircraft changed (Snook, 2000). Snook explains that instead of assigning a single code for the entire duration of the flight, the ATO now assigned one code to be used en route and a different code to be used while inside the TAOR. However, Eagle Flight and all U.S. Army UH-60 pilots were unaware of this change in procedure because the ATO they received only had the en route code listed (Snook, 2000).

this (Leveson, 2012). Thus, if a mechanical error resulted in the failure of Tiger 01 and 02's sensors to detect Eagle Flight's Mode IV, this information gap was caused by a failure of data, Eagle Flight's Mode IV codes, to ascend to Tiger 01 and 02's oval 2 because of a malfunction in the sensor. Again, an uncertainty-based information gap originated: Tiger 01 and Tiger 02 did not detect the friendly Mode IV IFF response from Eagle Flight. This gap is illustrated in Figure 13.

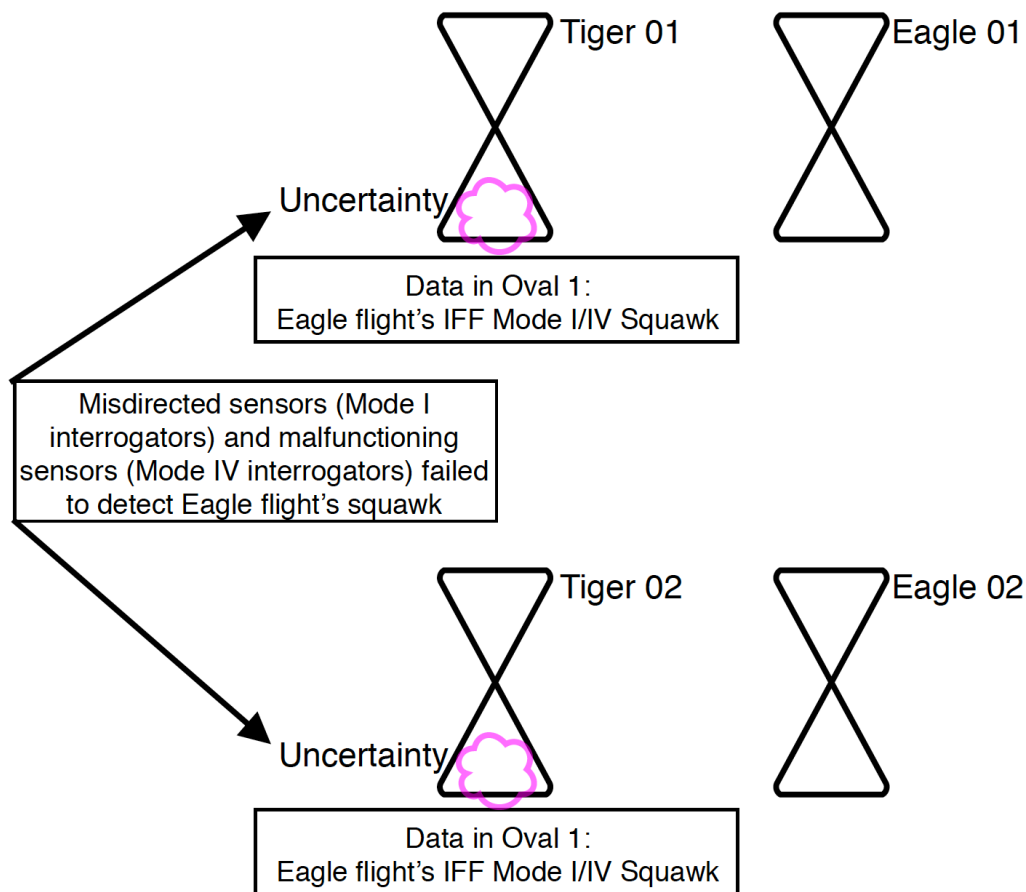


Figure derived from sources outlined in Chapter IV, Section B2b.

Figure 13. Uncertainty in Iraq

c. Complexity-Rooted Information Gaps: The UH-60's Distinguishing Characteristics

The visual identifying characteristics of the two U.S. Army UH-60s that distinguish them from Iraqi Hinds were not detected by Tiger 01's sensor, his eyes, during the visual identification (VID) pass (Snook, 2000). The resulting gaps in oval 2 were incorrectly filled in at oval 4 and caused Tiger 01 to form the wrong comprehension of the helicopters in oval 5. During the VID pass, Tiger 01 was saturated with inputs or sensor data from oval 2: instrument gauges, radio transmissions, and visual inputs from his recognition guide, the two helicopters and the surrounding terrain. The pilot recalled "I was trying to keep my wing tips from hitting mountains and I accomplished two tasks simultaneously, making a call on the main radio and pulling out a guide that had the silhouettes of helicopters. I got only three quick interrupted glances of less than 1.25 seconds each" (Leveson, 2012, p. 131). Tiger 01's past experience and expectations directed the orientation of his sensors during the pass. Training had taught him "that three distinguishing features of Hind helicopters are their tapered empennage, a rear-slanting tail, and ordnance-carrying sponsons" (Snook, 2000, p. 78). During the fly by, the features of the helicopter that Tiger 01 detected were exactly those: a tapered empennage, a sloped tail, and sponsons (Snook, 2000). Tiger 01 continued to explain what he did not observe during the pass, "I can only see the tip and the tail of the ordnance, not the actual ordnance, coming out from each side of the sponson. There's no markings" (Snook, 2000, p. 72). The UH-60s did, however, have markings: a total of six American flags painted on the doors, nose, underside and sponsons (Leveson, 2012). Additionally, UH-60s have a side-by-side cockpit compared to the Hind's tandem cockpit. The lack of detection of these characteristics; fuel tanks instead of ordnance, American flags, and side-by-side cockpit; and the fact that Tiger 01 expected to see a Hind (his lenses A and B) caused him to fill in his expectations into oval 4. Snook (2000) agrees that Tiger 01 incorrectly generated the contents of oval 4 based on his lenses when he describes Tiger 01's perceptions after the pass; "[t]here were, no doubt, a few gaps to fill in, some lines to read between, and several missing pieces of the picture to complete" (p. 78). Expectation filtering caused him to group those characteristics together, forming a comprehension of two Hinds in oval 5, which he reported to the AWACS and his wingman: "ID Hind, Tally [*sic*] two, lead trail, TIGER 02, confirm Hinds" (Snook,

2000, p. 63). The complexity-rooted information gap that resulted from expectation filtering is depicted in Figure 14. The feedback loops of the command DMSC model are illustrated by the lead pilot's instruction to his wingman to confirm the identification. The unquestioning feedback the AWACS TAOR controller provided, "Copy Hinds [,]" reinforced Tiger 01's oval 5 even though it was only an acknowledgement of the transmission (Snook, 2000, p. 63).

During Tiger 02's VID pass, which was conducted 400 feet farther from the helicopters than Tiger 01's pass, his sensors, his eyes, detected "high engines, the sloping wings, the camouflaged body, no fin flashes or markings" (Snook, 2000, p. 90). This information ascended to Tiger 02's oval 4, but unlike Tiger 01, Tiger 02 did not fill in the gaps in oval 4 with what he expected to see. Tiger 02 testified, "I did not identify them as hostile-I did not identify them as friendly. I *expected* to see Hinds on the call my flight leader had made. I didn't see anything that disputed that.... I called, 'Tally two,' at that point and the ID was based on what my flight leader called" (Snook, 2000, p. 90). Though Tiger 02's radio call only meant he saw the two helicopters, Tiger 01 interpreted it to mean his wingman agreed with his ID of the helicopters as Hinds (Snook, 2000).

The disagreement between the competing frameworks of Tiger 01 and Tiger 02 is also an example of equivocality. Equivocality, identified in Chapter II, Section F4, presented when Tiger 01 and Tiger 02 took the similar contents of their oval 4s and grouped them differently in oval 5. Tiger 01 arranged them to form a Hind, while Tiger 02 only arranged them to form a helicopter. This subtle difference between the two pilots' oval 5s, resulting from the unique differences between two pilots' lens Bs, had catastrophic results.

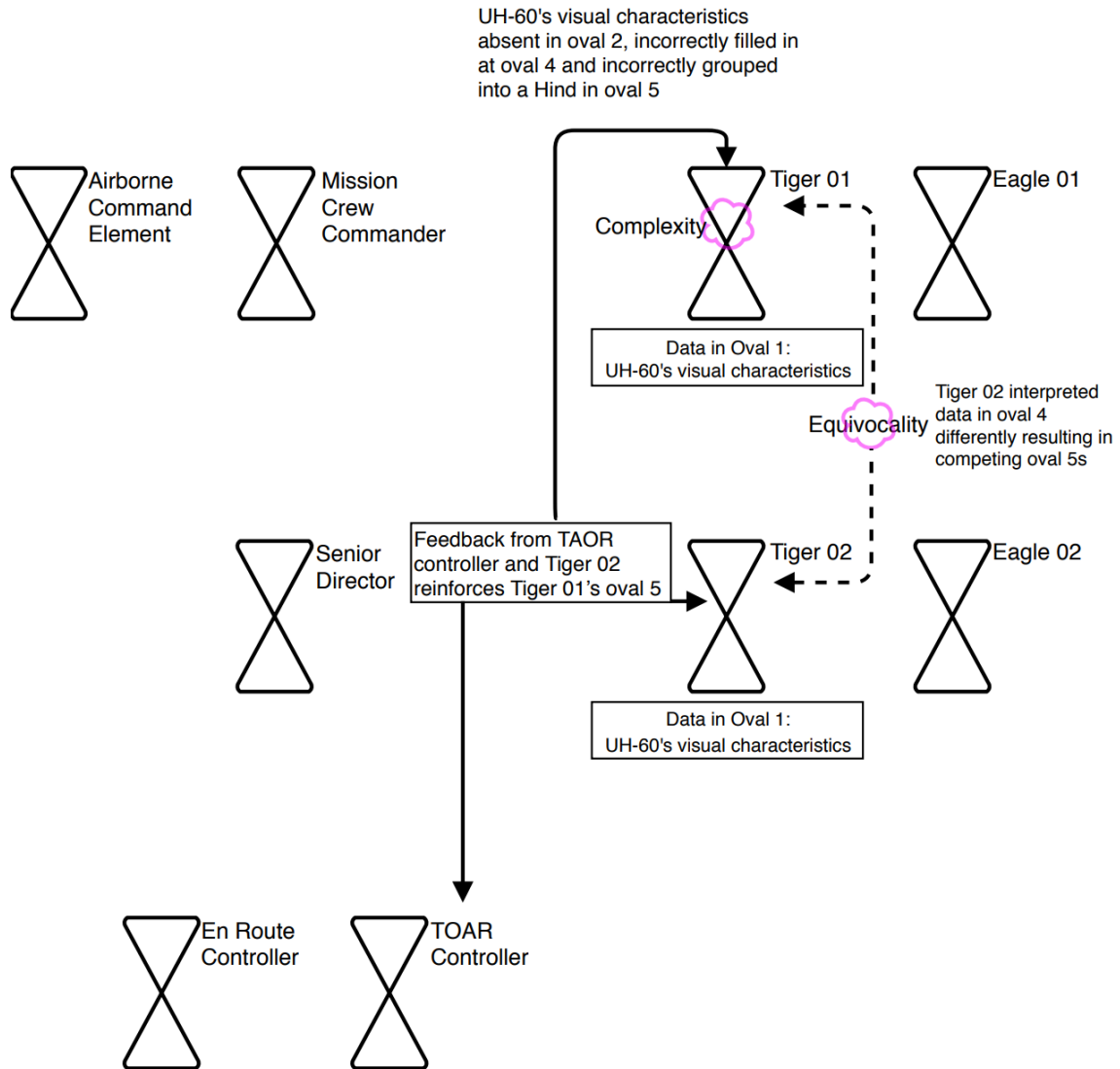


Figure derived from sources outlined in Chapter IV, Section B2c.

Figure 14. Complexity in Iraq

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V. SUMMARY AND FUTURE WORK

A. CONCLUSIONS

The goal of this thesis was to develop a model illustrating the creation and propagation of information gaps in a command structure in order to provide staffs and commanders a tool to identify and mitigate organizational blind spots. While presenting the vision for the future of information environment operations, the USMC (2017) advocates that “experimentation should focus on discovering and integrating state-of-the-art IM/KM [information management and knowledge management] tools, techniques, and procedures to give the IMO/KMO [information management officer and knowledge management officer] the ability to better affect the MAGTF’s operational tempo and advantage” (p. 34). This call for tools to manage the ever-increasing data and information flooding analysts, advisors, and decision makers drove the model’s development and testing.

Before looking at the processes and relationships that affect the flow of actionable information to the decision maker, this thesis examined how commanders make decisions. Experienced individuals make decisions by identifying similarities between elements of the current situation and situations they have faced in the past and then visualizing and evaluating potential actions (Klein, 1999). This approach to decision-making, which Klein observed and called the recognition-primed decision model, is not limited just to commanders. Analysts and advisors are experienced doing their specific jobs. Thus, staff members at all levels, who each make their own decisions that affect the collection, filtering, and processing of data, employ it. The recognition-primed decision model provided insight about each staff member’s interaction with data. The DMSC examines how individuals collect specific data from the environment, filter that data using lenses, and process it to make decisions (Shattuck & Miller, 2006). Placing the individual DMSCs of staff members in the layered command structure model presented by Leedom (2003) resulted in the command DMSC introduced and evaluated in this thesis. The command DMSC traces data from initial collection to its transformation into actionable information used by the commander. The potential causes of data’s failure to ascend the command

DMSC, defined as information gaps, were then identified and classified as uncertainty, complexity, ambiguity, or equivocality (Zack, 1999).

Chapter IV evaluated the command DMSC's ability to identify and explain the causes of information gaps. Application of the model to seven examples from two dissimilar historical cases showed the model's utility in varying command structures and environments. Critical data, that if available to the decision maker may have changed the outcome, was identified. That data was then traced as it ascended and eventually stagnated in the command DMSC. Attribution of data's failure to ascend the model in all seven examples to the kinds of information gaps identified in Chapter II demonstrates the model's validity.

1. Utility in Varying Commands

The model proved useful in identifying information gaps in both the rigid command structure of the German military in World War II and the ambiguous command relationships between the aircraft crews in the NFZ of northern Iraq. Comparing the cause of the information gaps present in the contrasting command structures revealed an interesting observation. In the rigid German military command, ambiguity arose from the presence of several of Davenport and Prusak's (1998) barriers to knowledge transfer. Conversely, in the loosely-defined command relationships between aircraft crews in northern Iraq, ambiguity emerged from an inaccurate understanding of individual roles and a lack of guidance from the unifying commander. This suggests that rigid command structures may be more vulnerable than flexible ones to certain knowledge transfer barriers such as distrust and recognition leading to information hoarding. Additionally, poorly-defined command structures may have an increased susceptibility to ambiguity-based information gaps because of implicit knowledge deficiencies that are created by misunderstood roles and an absent commander's framework.

2. Utility in Varying Environments

The cases selected in this thesis established that the model functions in varying environments. The utility of the model remained unaffected by the technological context of the cases used to test it. Analysis showed that uncertainty-rooted information gaps can

just as easily stem from a lack of 20th-century weather sensors as it can from the malfunction or improper configuration of the most current aircraft IFF equipment. The model is timeless and can be used as technology advances. The tempo with which each case unfolded also did not affect the ability of the model to identify information gaps. The lead F-15C pilot experienced complexity in a matter of seconds during his VID pass. Conversely, Colonel von Roenne's wavering, as reports suggesting both Normandy and Pas de Calais as the invasion site flowed in over multiple days, demonstrated that complexity-rooted information gaps are not limited to situations with limited processing time. Lastly, the successful application of the model to both strategic and tactical cases demonstrates that the model can be used at all levels of war.

B. ADDITIONAL FINDINGS AND LIMITATIONS OF THE MODEL

1. Fit of Existing Commands into the Model

The existing command structure does not always fit perfectly into the organization laid out by the command DMSC. The model uses three levels: a commander, a set of principal advisors, and a staff of technical specialists. There may be, however, multiple layers of advisors between the technical specialists and the commander. Additionally, the model only depicts three principal advisors subordinate to the commander and three technical specialists subordinate to each advisor. Application of the model to existing commands requires adaptation. During placement of the German meteorological functional area in the construct of the command DMSC, Colonel Walther Strobe served as a principal advisor to two separate commanders. In the arrangement of aircraft crews in northern Iraq, the lack of a single unifying commander on scene resulted in multiple decision makers at the highest level of the model. Knowledge transfer in this case also deviated from that depicted in Figure 4. Instead of remaining compartmentalized to each functional area, communication between Tiger 01 and the TAOR controller demonstrated cross-functional area communication as well as cross-hierarchical levels of communication. The model provides an initial framework on which to hang the existing command structure and begin to preemptively analyze for gaps.

2. Gaps Can Cause Gaps

Analysis revealed the multiplicative nature of information gaps. Gaps can propagate through the model because of uncollected, filtered, or ignored data, as Shattuck and Miller (2006) point out. They can also cause the introduction of new gaps through feedback loops that reorient sensors and reconfigure systems. The uncertainty-based information gap created by Colonel von Roenne's doubling of Allied strength estimates resulted from feedback loops. This exemplifies an ambiguity-based information gap leading the creation of new uncertainty-based information gaps. This thesis focused on the creation and ascension of gaps and their effects higher in the model, but this observation reveals the recursive nature of gaps that should be further explored.

C. FUTURE WORK

Testing of the command DMSC using examples from the historical cases confirmed its utility in identifying information gaps. The next step is validating the model by applying it to a staff during a live exercise. The command element of a Marine expeditionary unit practicing the rapid response planning process or the staff of a Marine expeditionary force (MEF) conducting a command post exercise such as MEFEX would provide a controlled environment to further evaluate the model. To accomplish such a validation would require several steps. These include arranging the staff in the framework of the model and taking inventory of the available sensors and systems. Next, the conscious and unconscious filtering of individuals and technology must be accounted for. The validation would also require tracking of what each individual understood as their role and the role of those around them and the guidance they received from their superiors in the model. Such steps would identify what can cause reorientation or recalibration of the sensors.

The primary role of the model explored in this thesis was to manage data and information inside one's own organization. Future work should focus on using the model to aid the conduct of deception operations. The USMC (2016) recognizes the need for "capabilities that deny the enemy access to critical information and associated systems/capabilities, and constrain the effectiveness of adversary decision-making processes" (p. 21). The command DMSC can be used to identify an adversary's information gaps, and

then fill them to manipulate his actions. The U.S. Army notes that “[u]nderstanding the target’s process for receiving and processing information, assessing a situation, and deciding a COA [course of action] is critical to a successful deception plan” (Department of the Army [DA], 2019, p. 1–4). It states that data on its way to the targeted decision maker travels multiple conduits and “that filters make every conduit unique, affecting the way information is transmitted through them” (DA, 2019, p. 1–4). It continues that to be successful, the deception message must be the same in each conduit and that planners must understand the weight the targeted decision maker applies to each conduit. Future research could guide deception planners in using the command DMSC to accomplish this process.

This thesis has shown that knowledge transfer and feedback loops are crucial to preventing information gaps. While the effect of command culture on knowledge transfer was investigated, other attributes of a command such as its level of rigidity, organizational age, and clarity of roles may affect knowledge transfer, feedback loops, and filtering decisions. The effect of a command’s attributes on these pieces of the model should be further researched to minimize an organization’s vulnerability to the gaps. Results of such research would provide insight when applying the command DMSC to the newly created MEF Information Group.

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