REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this 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 Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. **PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.**

1. REPORT DATE *(DD-MM-YYYY)* 10-10-2006

2. REPORT TYPE FINAL

3. DATES COVERED *(From - To)*

4. TITLE AND SUBTITLE
Overcoming Ambiguity at the Operational Level

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Jeffrey J. Krupka

Paper Advisor (if Any): Christopher Gregor and CAPT Santiago Neville

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Joint Military Operations Department
Naval War College
686 Cushing Road
Newport, RI 02841-1207

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Distribution Statement A: Approved for public release; Distribution is unlimited.

13. SUPPLEMENTARY NOTES A paper submitted to the faculty of the NWC in partial satisfaction of the requirements of the JMO Department. The contents of this paper reflect my own personal views and are not necessarily endorsed by the NWC or the Department of the Navy.

14. ABSTRACT

Overcoming Ambiguity at the Operational Level. Leaders are forced to make decisions with imperfect information on a regular basis. Time constraints necessitate action before complete information can be obtained. Other decisions must be made based on ambiguous information that can be interpreted in multiple ways. Both the nature of the decision and the information used as input play an important role in determining where, organizationally, the decision should be made. Bayes' formula for contingent probabilities is useful for demonstrating how organizational decisions can impact rational decision makers faced with ambiguity by demonstrating how expectations are revised with new information. When taking other operational considerations into account, it may also be useful for identifying decisions that should be made in certain locations. Once an optimal decision point is identified, the operational commander should allocate resources and establish procedures to properly align his staff.

15. SUBJECT TERMS
Decision making, analysis, decision assignment, ambiguity, uncertainty, Bayes, intelligence

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
					Chairman, JMO Dept
a. REPORT	b. ABSTRACT	c. THIS PAGE			19b. TELEPHONE NUMBER *(include area code)*
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED		21	401-841-3556

Standard Form 298 (Rev. 8-98)

NAVAL WAR COLLEGE
Newport, R.I.

Overcoming Ambiguity at the Operational Level

by

Jeffrey J. Krupka

Lieutenant Commander, United States Navy

A paper submitted to the Faculty of the Naval War College in partial satisfaction of the requirements of the Department of Joint Military Operations).

The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College or the Department of the Navy.

Signature: ____________________________

02 October 2006

List of Tables

Abstract

Overcoming Ambiguity at the Operational Level. Leaders are forced to make decisions with imperfect information on a regular basis. Time constraints necessitate action before complete information can be obtained. Other decisions must be made based on ambiguous information that can be interpreted in multiple ways. Both the nature of the decision and the information used as input play an important role in determining where, organizationally, the decision should be made. Bayes' formula for contingent probabilities is useful for demonstrating how organizational decisions can impact rational decision makers faced with ambiguity by demonstrating how expectations are revised with new information. When taking other operational considerations into account, it may also be useful for identifying decisions that should be made in certain locations. Once an optimal decision point is identified, the operational commander should allocate resources and establish procedures to properly align his staff.

Introduction

Successful decision making is the key to the formulation and implementation of any plan from the tactical to strategic level. While most tactical decision makers frequently face considerable constraints with regard to time, resources, options, and objectives, operational commanders have more leeway. Theater-level commanders have considerable latitude for establishing goals as well as allocating resources and setting procedures to realize those goals. Despite this leeway and the obvious utility of deliberate planning, decisions are frequently made under less than optimal conditions with significant ambiguity, especially as crises develop or operating environments evolve. Ensuring decisions are made at the most optimal level of command in an organization is critical. Commanders should actively oversee a deliberate structural plan to ensure those most capable have the authority and responsibility to make decisions or to at least provide the core analytical support to key decision makers.

The commander considers many factors in determining where decisions should be made in his organization. The nature of the information upon which decisions are based must be carefully weighed as it generates important implications as to who is most capable of using the input effectively. Ignoring the ramifications of ambiguity risks creating significant deficiencies and may result in poor, but avoidable, choices. Placing decision authority with those most capable of handling ambiguity can help manage this risk.

The difficulty of protecting U.S. forces from terrorist threats is an effective example of the importance of the proper assignment of decision authority. Terrorism analysis has always been fraught with considerable uncertainty stemming from limited information, questionable sourcing, and an ever-changing threat. A move towards smaller, less permanent bases; frequent short-term deployments; and the presence of U.S. forces in new environments from Kyrgyzstan to Djibouti aggravates these analytical challenges. Ensuring decisions are made at the optimal point will not reduce ambiguity but will help ensure those most capable of overcoming it are directly involved in supporting the ultimate decision maker.

Operational commanders must identify decisions involving high levels of ambiguity and ensure they are made at an appropriate level with adequate resources. Understanding the source of ambiguity and its affects can assist in this effort and help optimize decision making. An analytical approach to determining the nature of ambiguous problems can help the commander successfully identify and deal with uncertainty.

The Impact of Imperfect Information

The New Oxford American Dictionary defines ambiguous as "open to more than one interpretation; having a double meaning."[1] Ambiguous information is different than incomplete information but creates similar problems in its assessment. In addition to forcing a decision based on imperfect data, ambiguity can inject inaccurate information into the analytical foundation of the process. Just as experience, training, and operational acumen are critical to time-sensitive operational decisions with incomplete information, ambiguity is most effectively mitigated with rigorous analysis by an experienced staff. While training, lessons learned or other references, and methodology are helpful, ambiguous information essentially creates time constraints and must be handled intuitively in a more "natural" (and less structured) setting.[2] Such an environment is characterized by

> Time pressure, high stakes, experienced decision makers, inadequate information (information that is missing, ambiguous, or erroneous), ill-defined goals, poorly defined procedure, cue learning, context (e.g., higher-level goals, stress), dynamic conditions, and team coordination.[3]

Operational commanders and their staffs clearly face many of these factors on a daily basis. The relative nature of time constraints is of particular note. While a staff officer weighing the risks of allowing dependents to return to Bahrain has virtually unlimited time compared to the a platoon leader whose unit is taking fire from an unknown source, ambiguous information without the prospect of clarity essentially creates a time constraint by necessitating a decision before adequate information is obtained. The intellectual methodology and capacity necessary to successfully navigate such situations are similar.[4]

Basing decisions on intelligence is especially prone to the problem of ambiguity. Definitive and decisive information that clearly proves a conclusion, as evidence does in a criminal case, is exceedingly rare. "Detective work and intelligence collection may resemble each other, but they are completely different."[5] Multiple issues cloud collected intelligence's ultimate meaning including sources, perspective, and access. In addition, those targeted by collection assets actively attempt to hide information and may even utilize deception to create additional confusion. Despite the most well articulated intelligence requirements, collection assets are finite in their capabilities, existence, persistence, and ability to provide required information within a desired timeframe. Despite this, operational commanders need to make decisions with ambiguous, but well understood and accurately presented, intelligence. Intelligence can not, even if apparently conclusive and unequivocal, relieve the commander of this responsibility; it can inform, never decide.

Optimal Decision Points

Numerous issues clearly affect where a decision should be made. Communications capabilities, both in terms of technology and capability to share and process information, are the most obvious issue. Some situations, such as that faced by the infantry platoon being ambushed, require instantaneous, nearly instinctive responses. A fighter pilot with real-time link connectivity must make his own decisions and could never respond to rudder guidance from higher authority during a dog fight. Subtle situational awareness derived from personal interaction is also difficult to convey. A civilian terrorist analyst at the Defense Intelligence Agency in Washington, D.C. may be better qualified to assess a specific source's historic credibility and reporting record than the individual augmentee deployed for 6 months but deployed forces will possess a better picture of the physical force protection concerns and level of cooperation with host nation security elements than anyone outside the local area, regardless of their expertise or connectivity. They will also see through the formal rhetoric of non-confrontational, high-level exchanges in their day-to-day interaction with their foreign peers. An emphasis on face-to-face interaction and the trust generated by long-term personal relationships also necessitates a local perspective to decision making. Some decisions are best made at the lowest level possible, especially if it involves a quickly changing environment or personal interaction.

Conversely, the availability of information or the scope and ramifications of the issue may bias the optimal decision point to higher authorities. Sensitive information requires careful dissemination controls which may preclude complete situational awareness to deployed analysts or decision makers. U.S. Navy destroyer captains are not able to receive highly compartmented intelligence while underway and must therefore rely on others to assess its potential operational impact on their units. Similarly, centralized facilities often maintain or retain access to databases, which may not be available to lower echelon units, which may provide key perspective in assessing information and its potential impact. Decisions often have ramifications beyond their local consequences. A subordinate commander's tactical or operational priorities may differ from overarching theater or strategic objectives. A port visit in Kenya sends a strategic message in the region more significant than the operational benefit of refueling. All these issues call for a more centralized decision point.

The level of expertise, as alluded to above, is a key factor in determining the appropriate level of decisions. In some cases, local capabilities or situational awareness dominates while in others a more strategic perspective or greater access to information is paramount. But increased access to national databases, the pushing of sensitive intelligence to operational and tactical units, interagency outreach to the Unified, Combatant, and Joint Task Force Commander level, along with a more personal and interactive approach of senior leaders and their staff help to blur these distinctions. Despite these changes, the very nature of information and the resulting ability of individual leaders or analysts to proficiently evaluate it should sometimes dominate the determination of where a decision should be made. These decisions should be made in staffs with appropriate resources and personnel continuity rather than in units with high turnover rates. Given the subjectivity of the assessment of such information, can the selected decision point's effect and potential ramifications on its utilization be demonstrated? When does long term experience predominate over the on-scene perspective available to temporarily deployed individuals or those serving in one year unaccompanied billets?

The Challenges of Ambiguity

Bayes' formula for contingent probabilities* is a useful construct for demonstrating the effects of ambiguous information on decision making. Bayes' equation is essentially a weighted average of expectations that allows for their deliberate and rational revision through the incorporation of new information using given probabilities of both type I (failure to detect an event) and type II (false detection) errors. This suggests that over time, divergent assessments of an ambiguous problem will converge towards the "correct" estimate for a given set of error rates. How quickly this occurs depends not only on the receipt of new information but also on

* Bayes' formula for contingent probabilities models changes in expected probability for evolving information given a set of understood rules. The concept can be best visualized with the following example (derived from the "Monty Hall problem"). Imagine a shell game where a ball is hidden underneath one of three identical cups. Selecting a cup at random results in a 1/3 probability of selecting the ball. Viewed in another way, the selected cup has a 1/3 chance of containing the ball while the other two cups as a group have a 2/3 chance of containing the ball (each cup has a 1/3 chance of having the ball under it.) If one of the two remaining cups is overturned to show no ball, the probabilities become less intuitive. The probability of the ball being under the initially selected cup remains 1/3 while the probability of the ball being under the remaining unselected cup is 2/3 (rather than the ½ probability that may be expected for two choices) because the initial division of the three cups into two groups and elimination of one of the choices in the second group. If offered the opportunity to switch guesses after being shown the empty cup, the probability of successfully guessing the location of the ball is maximized by choosing the other cup. Bayes' formula incorporates changing information into given probability sets and models the systematic evolution of expectations, as expressed by probabilities. The "Monty Hall problem" is described on numerous internet sites, fairly intuitively at http://www.reference.com/browse/wiki/Monty_Hall_problem but also at academic-related sites such as http://astro.uchicago.edu/rranch/vkashyap/Misc/mh.html or http://www.math.brown.edu/~jonathan/monty-hall.pdf#search=%22bayes%20%22Monty%20Hall%20problem%22%22.

the error rates which generate changes in expectations in a manner consistent with how reliable new information is assessed to be. An analyst or decision maker will be influenced less by suspect information (that with a higher probability of type II errors) than input deemed more reliable and he will change his assessment in the face of additional information more carefully (i.e., slower.)

Bruce Blair of the Center of Defense Information highlights the utility of Bayes' analysis in understanding how expectations are changed. He emphasizes how uncertainty can lead to poor initial assessments when decision makers fuse data with their own perceptions to reach a conclusion. Subjective opinion and preconceived notions are highly influential in formulating an assessment and making a decision.[6] The impact of this is manifested when dealing with a new problem before the lessons of experience are incorporated. The rational decision maker overcomes initial bias in a logical manner as additional information is systematically included in his assessment. The formula for contingent probabilities not only shows how this takes place but demonstrates how long the process of developing new expectations will take. Highly ambiguous problems combined with a relatively inexperienced decision maker create the potential for inaccurate assessments, even when expectations are revised in a rational, logical manner. The ramifications of such errors depend on the nature of the problem and the length of time it takes for a change in assessment to occur.

Assessing the likelihood of a terrorist attack can be used to demonstrate this process. Blair uses the following form of Bayes' theorem to show the evolution of expectations of the likelihood of an imminent attack in the face of repeated reports predicting an attack:

$$NewP(A) = \frac{P(W \mid A) * P(A)}{P(W \mid A) * P(A) + \left[P(W \mid NA) * \{1 - P(A)\}\right]}$$ [7]

Where
P(A) = the perceived probability of attack

P(W|A) = the probability of warning of an impending attack
P(W|NA) = the probability of warning given no attack
NewP(A) = revised expectations after receiving warning

Of note is the relationship of *known* error rates to these coefficients. P(W|A) is the inverse of the probability that an attack will not be detected (1 – the probability of type I error) while P(W|NA) is the probability of type II error (receiving a false warning). For example, if the probability that an impending terrorist attack will not be detected (type I error) is .25, the probability that the attack will be detected is .75. For illustrative purposes, assume a probability of receiving a false alarm (type II error) of .25. Using these parameters, an analyst or leader attempting to assess the likelihood of a terrorist attack would expect warning of an impending attack 75% of the time while also expecting that any otherwise credible* report is false 25% of the time.

Table 1 demonstrates how expectations of the likelihood of an attack, P(A), evolve as additional credible reports predicting an attack are received. The initial assessment of the likelihood of attack can be any non-zero probability. A number of issues can be inferred from Table 1. Given a negligible initial assessment of the probability of attack, 18 credible reports of an impending attack must be received to completely convince a skeptic that an attack is imminent.

More significant is the magnitude of change of P(A) for two individuals with similar but divergent initial assessments of the likelihood of attack. Both are highly skeptical but one believes the probability of attack is just under 7% (.068) while the other believes the probability to be under 1% (.008). In layman's terms, each would view an attack as unlikely and would appear to be in concurrence when discussing the potential for terrorist activity. Despite this

* A basic competence in distinguishing between credible and non-credible reporting is assumed in this case. Obviously this is a critical issue in the evaluation of ambiguous information, especially terrorist threat reporting. Later, the ramifications of an inability to make this determination will be examined.

seeming agreement, the rational revision of their expectations in the face of four credible reports creates a significant divergence in assessments between the two individuals. Their revised assessment can be identified by counting down on Table 1 beginning from the initial assessment (P(A)) for each additional report. That starting at .068 revises his assessment to .8552 while the .008 starting point is only raised to .3962. Both have significantly increased the assessed likelihood of attack but the disparity of their assessments has increased from .057 initially (.065-.008) to .459 after additional reporting is received and incorporated (.8552-.3962). One (with a revised assessment of .3962) now believes the odds of attack are less than 50-50 while the other views an attack as probable (.8552).

Table 1: Perceived Likelihood of Attack for P(W|A)= .75 & P(W|NA) = .25

Reports	P(A)
Initial	0.0001
1	0.0003
2	0.0009
3	0.0027
4	0.0080
5	0.0237
6	0.0680
7	0.1795
8	0.3962
9	0.6631
10	0.8552
11	0.9466
12	0.9815
13	0.9938
14	0.9979
15	0.9993
16	0.9998
17	0.9999
18	1.0000

Actions taken by these individuals to mitigate such an attack would be radically different given their divergent views after four warnings. If the frequency of receipt of credible terrorist reporting is low, forces could be poorly postured for the actual threat for quite some time before additional reporting convinces the skeptic to take action, hopefully before an actual attack occurs. Dealing with ambiguity poorly has placed forces at risk. From an organizational standpoint, imagine the effects if the individual with the lower initial P(A) has just relieved the other. A lack of continuity has created significant, avoidable risk with no discernible indications. Minute differences in the initial perception and assessment of a threat have profound implications when compounded over time.

Turnover has potentially put forces at risk. Making this decision at a higher level would allow for greater continuity of personnel and a more consistent assessment of the threat. Ambiguity can not be eliminated but the careful placement of decision authority at the proper level can manage the risk more effectively.

Changes in the probability that warning will be received of an attack (P(W|A)) or in the probability that a warning will be a false alarm (P(W|NA)) affect the speed at which the assessment of the likelihood of attack is revised. An increase in the probability of receiving warning (P(W|A) of an attack is indirectly correlated with the probability that an attack will not be detected (type I error). The closer correlated the warning is to the actual event, the more one will value the input in formulating expectations. This is intuitive. For example, gathering storm clouds accompanied by thunder and lighting are excellent indications of rain in the near future. The corresponding P(W|A) of such an indicator would be quite high, approaching unity. If one were to receive such warning (observing clouds, lighting, and thunder) they would roll up the windows in their car regardless of their initial expectations for the day's weather. Conversely, as P(W|A) decreases, it is less relevant for predicting future events and has less impact in the revision of expectations. More reports are required to convince.

Table 2: Effects of an Increase in P(W|A)

P(A) for P(W|A) = .75	Reports	P(A) for P(W|A) = .90
0.0001	Initial	0.0001
0.0003	1	0.0004
0.0009	2	0.0013
0.0027	3	0.0046
0.0080	4	0.0165
0.0237	5	0.0570
0.0680	6	0.1788
0.1795	7	0.4394
0.3962	8	0.7383
0.6631	9	0.9104
0.8552	10	0.9734
0.9466	11	0.9925
0.9815	12	0.9979
0.9938	13	0.9994
0.9979	14	0.9998
0.9993	15	1.0000
0.9998	16	
0.9999	17	
1.0000	18	

Table 2 demonstrates an increase in P(W|A) as compared to the previous case with the probability of false alarms (P(W|NA)) constant. The increase in the probability of a warning results in the quicker revision of expectations. Only 15 reports are required to change from being convinced an attack will not occur to being certain one will when P(W|A) = .9 while 18 were required when P(W|A) = .75. While the disparity of assessment increases as additional information is received for individuals with different initial estimates, it is less acute than in the previous example due to the greater significance placed on each warning report from its increased reliability. More accurate indicators not only let decision makers revise their expectations quicker but decrease disparate assessments as additional information is received.

An increase in the likelihood of false alarms, or type 2 error (P(W|NA)), decreases the credibility of new information and leads one to more caution in revising expectations. Table 3 demonstrates this issue; for a P(W|NA) .35, 26 reports (rather than 18) are now required to change one's mind for near uncertainty to certainty. As skepticism of the reporting increases, its effect on the assessment of the likelihood of attack continues to decrease. Questionable information is less influential.

Table 3: Effects of an Increase in P(W|NA)

P(A) for P(W|NA) = .25	Reports	P(A) for P(W|NA) = .35
0.0001	Initial	0.0001
0.0003	1	0.0002
0.0009	2	0.0005
0.0027	3	0.0010
0.0080	4	0.0021
0.0237	5	0.0045
0.0680	6	0.0096
0.1795	7	0.0203
0.3962	8	0.0426
0.6631	9	0.0870
0.8552	10	0.1695
0.9466	11	0.3043
0.9815	12	0.4839
0.9938	13	0.6677
0.9979	14	0.8115
0.9993	15	0.9022
0.9998	16	0.9518
0.9999	17	0.9769
1.0000	18	0.9891
	19	0.9949
	20	0.9976
	21	0.9989
	22	0.9995
	23	0.9998
	24	0.9999
	25	0.9999
	26	1.0000

Also of interest is the affect as the value of P(W|NA) (the likelihood the warning is a false alarm) approaches and eventually exceeds P(W|A) (the likelihood of warning for an attack). Table 4 highlights this relationship*. When the probability of a report being false is equal to the probability that it will foretell of an attack (P(W|NA = P(W|A)), new information is essentially useless: it will not lead to a change in assessment. Again, this is expected since the chance of new information being accurate is the same as it being inaccurate. When P(W|NA) exceeds P(W|A) the chance that the information is inaccurate is greater than the chance it will correlate

* Note that the initial expectation in this table has been changed to .5000 to help illustrate the effects of an extremely high P(W|NA).

P(A) for P(W|NA) = .75	Reports	P(A) for P(W|NA) = .85
0.5000	Initial	0.5000
0.5000	1	0.4688
0.5000	2	0.4377
0.5000	3	0.4072
0.5000	4	0.3774
0.5000	5	0.3485
0.5000	6	0.3206
0.5000	7	0.2940
0.5000	8	0.2687
0.5000	9	0.2448
0.5000	10	0.2224

Table 4: Effects of an Extremely High P(W|NA)

to an actual attack. Additional reporting of especially unreliable information actually leads to a decrease in the assessed probability of attack.

This organizational relevance of this relationship is not immediately apparent. If the decision maker has no control over the information received to warn of an attack, an extremely high likelihood of false positives makes the reporting useless. In the real world, this is not typically the case. A decision maker or analyst will cull the useless data and only consider the relevant and more reliable, or credible, information. This will lower P(W|NA) (the chance of false alarms) and make the remaining information more influential (since it is less likely to be inaccurate.) The distinction between good and bad data is difficult and is accomplished more successfully as experience and knowledge increase.[*] For the problem of using intelligence to predict a terrorist attack, any number of issues could help eliminate non-credible reporting including specific knowledge of the source, the feasibility of details of the report, or concurrent intelligence. The more familiar one is with a problem, the easier it is to discard outlying information and assemble a more useful set of indicators.

The 2001 edition of Joint Publication 3-0 (JP 3-0), *Doctrine for Joint Operations*, clearly places responsibility for maintaining strategic estimates, to include threat analysis, at the combatant commander level.[8] This would appear to place responsibility for anti-terrorism analysis at the combatant commander level where resources and personnel continuity can provide the level of analytical acumen suggested as optimal by the above analysis. The 2006 revised addition is less

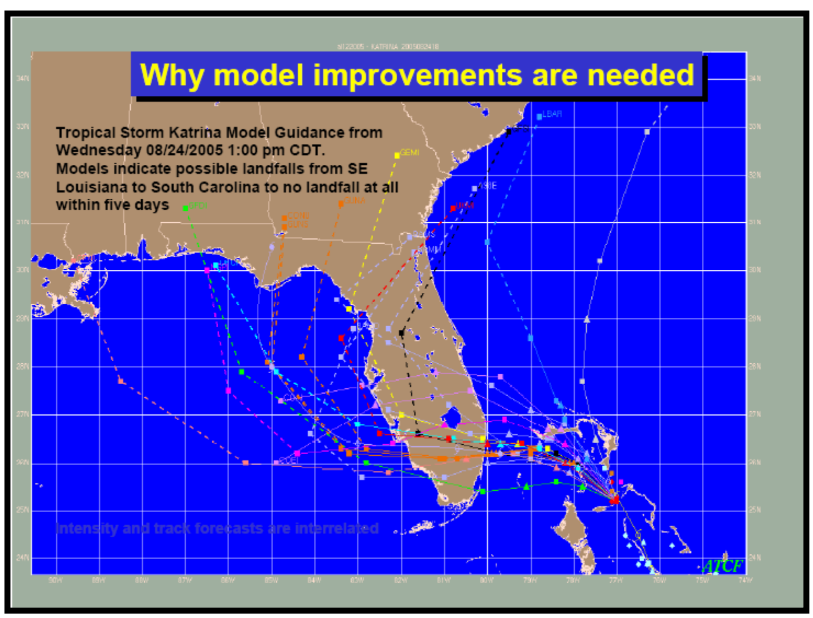
[*] An interesting aside is the demonstration of how data set selection can influence P(W|NA). Opinion can be manipulated not only through withholding information but also through the inclusion of less reliable information to cloud the value of the reliable information within the greater data set. Bayes' formula thus demonstrates this phenomenon's potential utility for the manipulation of opinion for information operations, deception campaigns, or simply to obfuscate a point.

definitive. Assessments are generally tied to specific operations rather than a general understanding of the theater from a threat perspective. The publication suggests that assessments should occur at the operational level where they will be used: "As a general rule, the level at which a specific operation, task or action is directed should be the level at which such activity is assessed."[9] This may be in conflict with the optimal decision point for terrorist threat analysis. While the revised JP 3-0 may be less definitive of where such analysis should occur, it by no means restricts the combatant commander from assigning such critical decisions as he sees fit - a prerogative that should be utilized without hesitation.

The use of predicting a terrorist attack to illustrate the ramifications of ambiguity does not limit this analysis to intelligence-related problems. Any issue involving significant ambiguity faces identical analytical issues. The case of Joint Interagency Task Force South (JIATF-South) attempting to determine when hurricane evacuations should be conducted highlights not only how ambiguity can be dealt with but also how a lack of local expertise can be mitigated.

Located in Key West, Florida, a single highway links JIATF-South to the mainland, and safety, during a hurricane. Predicting the path of an approaching storm is extremely difficult especially given the timeframe required to prepare for and conduct an evacuation along a single line of communication (the typical time of travel from Key West to the mainland is almost three hours

Figure 1: Predicted Path of Tropical Storm Katrina, 24 August 2005



given normal traffic.) Decisions for evacuation are made in conjunction with the base commander and local authorities. Lacking organic hurricane experts, JIATF-South initially relied on support from Navy meteorologists also stationed in Key West and external estimates of a storms predicted path. When the local meteorological office was closed, JIATF-South established new billets on its staff for meteorologists but still relied on external support for hurricane track analysis.

Figure 1 shows predicted paths of Hurricane Katrina on 24 August 2005[10] varying from Louisiana to never making landfall and remaining in the Atlantic Ocean.[*] Even within this large range of possible paths, the intensity (as important to the evacuation decision as the path), exact path, and local affects (to include tidal surges) of a hurricane change quickly. While JIATF-South wisely addresses the lack of local expertise by seeking outside support to help mitigate the risk of ambiguity, the best analysis available may still be of limited utility given the required time to execute an evacuation.

In terms of Bayes' model, any predicted path for a hurricane contains both a low P(W|A) (the probability the predicted path will accurately indicate if the storm will hit Key West) along with a high P(W|NA) (the probability that the prediction is wrong) with little prospect of eliminating ambiguity – a worst case scenario for any leader. (In this case, instead of warning of an attack, the model would be warning of the hurricane coming close enough to warrant evacuation.) As a result, JIATF-South and the local base utilize a set of criteria to trigger an evacuation to minimize the subjectivity of any decision.[11] Additionally, the significant costs of evacuation are incorporated into the long range plans of the organization by its leadership. Unable to eliminate significant ambiguity with serious real-world consequences, JIATF-South

---

[*] Hurricane Katrina made landfall during the morning of 29 August 2005 in New Orleans – at the western extreme of the predicted paths on 24 August.

has deliberately developed and refined an effective organizational plan to protect its operation and personnel through risk mitigation.[12]

While external analysis is critical for storm path assessment, JIATF-South must maintain the decision authority for evacuation due to local, personnel, and tactical requirements. The current plan addresses these issues through planning, standard operating procedures, budgeting, and specific external support. The plan carefully addresses conflicting priorities and realities while mitigating ambiguity as identified by a Bayesian analysis of the problem.

Impact for the Operational Commander

Ambiguity is not avoidable but like other risk it is manageable. Thoughtful action by a commander can help to decrease ambiguity or lesson its impact on operations if successfully integrated into an organization's architecture. Careful analysis of decisions consistently plagued by ambiguity along with a clear plan and consistent application can attenuate risk. A deliberate approach to studying ambiguous problems and identifying solutions will make an organization more capable of handling uncertainty.

Identification of decisions prone to the dangers of ambiguity is crucial. Some issues are readily apparent, such as the examples already highlighted, while others are less clear. Assigning actual values for type I and type II error is impossible in the real world, yet estimates can be formulated to approximate these variables in comparison to more routine, and less troublesome, issues. Problems with high rates of estimated type II errors ($P(W|NA)$ in the Bayesian analysis above) are potential candidates for additional study, especially if increased attention can help decrease the rate of false alarms.

Assignment of decisions to the appropriate level can help mitigate the risk of ambiguity. Higher echelon elements in a theater have greater resources and personnel continuity than forward deployed forces. Conversely, deployed forces have greater situational awareness and knowledge of subtleties only available "on the scene." For example, while the complexity of terrorism analysis clearly calls for a more experienced staff, not all complex decisions do. Force protection decisions are equally complex but the necessity for rapid adjustment of posture and local situational awareness call for a decentralized approach. In all cases, communication between both levels of command should remain open to ensure a unity of effort, knowledge, and expectations.

If decision authority can not be moved, higher authority or external organizations could provide outside analytical support for the responsible commander. Operations and intelligence watch centers at all the unified commands provide this support to task forces and units in their area of responsibility. In such cases, clear guidance and assignment of responsibility must be given to all units involved to avoid confusion.

Once a determination has been made to base a decision at a certain point, the commander must ensure it does not change without his consent, either formally or informally. If a decision is to be made at headquarters on paper but in reality is determined primarily through input from deployed forces, true decision authority has not been moved and risk will not be managed as planned.

Standardization can help address ambiguity as demonstrated by the JIATF-South case. Standards or checklists can help force decisions at earlier stages while issues remain less clear but before they can produce significant negative consequences. However, such procedures will most likely err on the side of caution and produce responses to developing situations that later prove to be unnecessary, as well as expensive.

Once established, standards must be maintained and can not be allowed to be changed or ignored without formal review and appropriate planning. The space shuttle Challenger disaster is an excellent example of how the unvetted evolution of standards led to the acceptance of more risk without formal review and consideration from an aggregate perspective.[13] The commander that implements standards must maintain authority over their relaxation.

Commitment of resources over time must be maintained to support the commander's plan for managing ambiguity. Personnel must be assigned to the problem, properly trained, and allowed to remain focused on their assigned issues. Using designated experts in other areas to support short term crisis erodes expertise and detracts from continuity over time. Resources must be allocated for training, databases, and communications infrastructure to ensure expertise and situational awareness is maintained.

Similarly, realistic budgeting priorities which account for the precautionary costs associated with standardized responses are critical. Without funding, responding in accordance with established standards could become impossible or negatively impact other important activities to compensate for unplanned expenses. A long term commitment must be made to maintain the capability to programmatically address ambiguity from an organizational perspective.

Conclusion

Bayes' formula for contingent probabilities is not only useful for demonstrating the consequences of ambiguity in decision making but also provides a conceptual foundation for identifying problematic decisions. Forewarned through the identifications of problems plagued by ambiguous information, the operational commander can take an organizational approach to mitigating the associated risks through decision point selection, the establishment of standards, and the commitment of resources to support such measures. This process should be staffed and implemented with the same priority as those taken to support operations. *Informational* risk management can be as important as operational risk management in the successful completion of mission objectives.

Selected Bibliography

Bar-On, Mordechai (eds.). *A Never-Ending Conflict: A Guide to Israeli Military History*. Westport: Praeger Publishers, 2004.

Berkowitz, Bruce. "The Big Difference between Intelligence and Evidence." *Washington Post.* 02 February 2003: B01.

Blair, Bruce G. "The Logic of Intelligence Failure." Center for Defense Information. http://www.cdi.org/blair/intel_failure.pdf (accessed 26 September 2006.)

Hoffman, Bruce. *Inside Terrorism*. New York: Columbia University Press, 1998.

Joint Interagency Task Force South, "Hurricane Briefing"

Klein, Gary. *Sources of Power – How People Make Decsions.* Massachusetts Institute of Technology Press, 1998.

Neustadt, Richard E. and May, Ernest R. *Thinking in Time – The Uses of History for Decision Makers.* New York: The Free Press, 1986.

Presidential Commission on the Space Shuttle Challenger Accident. Report on the Space Shuttle Challenger accident. Washington D.C., 06 June 1986: Chapter 6. http://history.nasa.gov/rogersrep/genindex.htm (accessed 30 September 2006.)

Notes

1. *The New Oxford American Dictionary*, 2001, s.v. "ambiguous."
2. Oransanu and T. Connoly. "The Reinvention of Decision Making" in G. Klein, J. Orasanu, R. Calderwood, and C.E. Zsambok (eds.), *Decision Making in Action: Models and Methods* (Norwood, NJ: Ablex, 1993), 3-20. Quoted in Gary Klein, *Sources of Power: How People Make Decisions* (Massachusetts Institute of Technology Press, 1998), 3. Klein contrasts more conventional decisions, highlighted by "deductive logical thinking, analysis of probabilities, and statistical methods" with skill needed in natural settings which "are usually not analytical at all—the power of intuition, mental simulation, metaphor, and storytelling."
3. Gary Klein, *Sources of Power: How People Make* Decisions (Massachusetts Institute of Technology Press, 1998), 4.
4. Ibid, 4.
5. Bruce Berkowitz, "The Big Difference between Intelligence and Evidence" (February 2, 2003 Washington Post), pB01. Also available at http://www.rand.org/commentary/020203WP.html
6. Bruce G. Blair, "The Logic of Intelligence Failure," Center for Defense Information, http://www.cdi.org/blair/intel_failure.pdf (accessed 25 September 2006).
7. Ibid.
8. U.S. Office of the Chairman of the Joint Chiefs of Staff. Doctrine for Joint Operations, Joint Publication (JP) 3-0 (Washington, DC: CJCS, 10 September 2001), I-9.

9. U.S. Office of the Chairman of the Joint Chiefs of Staff. Doctrine for Joint Operations, Joint Publication (JP) 3-0 (Washington DC: CJCS, September 2006), IV-31.

10. Joint Interagency Task Force South J4, "Hurricane Briefing," slide 21, http://www.jiatfs.southcom.mil/j4/hurricane/Hurricane%20Brief%202006.pdf (accessed 29 September 2006). Ultimate source of the graphic is unknown but is based on various models of predicted storm path and intensity from numerous sources.

11. Ibid, slide 89.

12. Rear Admiral Jeffrey J. Hathaway, USCG, Director Joint Interagency Task Force South, email messages to author, 02 October 2006.

Colonel Neal R. Carbaugh, USAF, Chief of Staff, Joint Interagency Task Force South, email message to author, 01 October 2006.

13. Presidential Commission on the Space Shuttle Challenger Accident, 06 June 1986, Washington, D.C., available at http://history.nasa.gov/rogersrep/genindex.htm (accessed 30 September 2006), p. 148, Chapter 6. The findings include

"NASA and Thiokol accepted escalating risk apparently because they 'got away with it last time.'"

As well as

"[The Shuttle] flies [with O-ring erosion] and nothing happens. Then it is suggested, therefore, that the risk is no longer so high for the next flights. We can lower our standards a little bit because we got away with it last time.... You got away with it but it shouldn't be done over and over again like that."