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INTELLIGENCE DATA MODEL FOR ADVANCED PLANNING AIDS

by

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June 2023

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INTELLIGENCE DATA MODEL FOR ADVANCED PLANNING AIDS

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Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

The purpose of this research is to define the adversary course of action supporting data model and how it relates to The Automated White Cell (TAWC), which is a theoretical advanced planning aid construct. Newly proposed operating concepts rely on smaller concentrations of forces with potentially more information to process. This model forces military leaders to rely on more intuitive decision making and/or use technology to support traditionally human analytical functions. For new technology to be a significant and reliable contributor to planning, software developers must consider doctrinal processes like the Intelligence Preparation of the Battlespace (IPB). Countless years of experience is imbedded in military publications and there is sparse literature on mapping doctrinal models of uncertainty reduction to leading technologies. This thesis explores how processes lead to discovery, therefore reducing surprises in a battlespace.

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LIST OF ACRONYMS AND ABBREVIATIONS

AAR	After Action Review
AO	Area of Operations
AOI	Area of Interest
AOInf	Area of Influence
ATP	Army Techniques Publication
COA	Course of Action
COG	Center of Gravity
COP	Common Operational Picture
DOD	Department of Defense
EMDCOA	Enemy Most Dangerous Course of Action
EMLCOA	Enemy Most Likely Course of Action
EVE	Event-Verb-Event
HPT	High Payoff Target List
HPTL	High Payoff Target List
HVT	High Value Target
HVTL	High Value Target List
ICD	Intelligence Community Directive
IPB	Intelligence Preparation of the Battlespace
IPOE	Intelligence Preparation of the Operational Environment
JIPOE	Joint Intelligence Preparation of the Operational Environment
JP	Joint Publication
MACV	Military Assistance Command Vietnam
MAUA	Multi-Attribute Utility Assessment
MCDP	Marine Corps Doctrinal Publication
MCPP	Marine Corps Planning Process
MCRP	Marine Corps Reference Publication
MCWP	Marine Corps Warfighting Publication
MOS	Military Occupational Specialty
OOB	Order of Battle
OPLAN	Operation Plan

OPORD	Operations Order
PED	Processing Exploitation Dissemination
PIR	Priority Intelligence Requirement
SAT	Structured Analytic Techniques
SIGACT	Significant Activity
TAWC	The Automated White Cell
TTP	Techniques, Tactics, and Procedures
USA	United States Army
USMC	United States Marine Corps

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I. INTRODUCTION

The modern command center is overwhelmed with information. Military personnel in these command centers attempt to transition data and information into knowledge, but the reality is that we collect more data and information than we can process. During the Vietnam War, the Military Assistance Command, Vietnam—a joint service command—received three million pages of enemy reports per month and only ten percent were deemed intelligence worthy (Van Crevald, 1985). Almost fifty years later, we have the same problem, but with more complexity.

The demand for information is not going away; in fact, the demand is increasing. Modern operational concepts like Distributed Maritime Operations and Expeditionary Advanced Base Operations require more sensing to support warfighting. There appears to be more emphasis on collection rather than making sense of the data. Adding more people to the process would increase the size of command centers which inherently creates more sustainment requirements; this is at odds with the previously mentioned concepts. To state the problem simply, we need less people to do more work.

The solution to this problem is the same as it has always been, to integrate technology to support human tasks. Contemporary research has integrated machine learning advancements into advanced planning aids and proposed theoretical frameworks for future development. The U.S. military needs to explore how these technologies can support tactical warfare. However, the integration of this technology will require substantial changes in current business rules, or standard operating procedures, used in command centers. Storing data in Power Points or random spreadsheets will not allow us to use these technologies to their full potential.

This thesis aims to examine our current intelligence processes as a means of inputs and outputs and map them to an advanced planning aid framework. Identifying the information relationships in intelligence planning processes is imperative in projections about adversary actions. Centuries of experience is aggregated into our warfighting

publications and any advanced planning aid needs to consider the collective knowledge formed through lessons learned.

A. METHODOLOGY

This thesis uses a qualitative research method that examines doctrinal intelligence processes and advanced planning aid theories. This includes developing a data model around the IPB and IPOE processes and how it can be integrated into an Event-Verb-Event (EVE) structure used by The Automated White Cell (TAWC) (Nagy, 2020).

B. PROBLEM STATEMENT

The problem is that military intelligence planners are overwhelmed by data which can increase risk factors by not turning unknown planning variables into knowns. This is a problem because surprise can spoil military plans and can increase the number of Gold Star Families and lead to mission failures.

C. PURPOSE STATEMENT

The purpose of this thesis is to support the development of advanced planning tools, such as TAWC, by mapping inputs and outputs of doctrinal intelligence processes. This is achieved through analyzing the processes that support military planning efforts, such as the intelligence preparation of the operational environment (IPOE) and the intelligence preparation of the battlespace (IPB).

Highlighting key inputs and outputs in intelligence support to planning will help advanced planning aid engineers represent related enemy behaviors through anticipated courses of actions (COAs). Furthermore, representing intelligence processes will more accurately represent the threat, leading to higher quality conditional probability-based assessments. This research is important because artificial intelligence and machine learning with game theory is limited by the quality of data provided by intelligence professionals and processes. These processes are proved to reduce uncertainty for decision makers, and it is imperative that it is incorporated into advanced planning aids.

II. LITERATURE REVIEW

This literature review provides background information in human-machine teams, intelligence support in military planning cycles, adversary modeling, defining uncertainty, and decision-making theory. The intent of this literature review is to capture how the intelligence community supports determining an adversary's possible courses of action and what information is imperative in making those determinations. Additionally, this chapter explores uncertainty management throughout the planning process.

The intelligence processes used to create an adversary course of action is influenced by many factors, such as the team, accessible technology, military doctrine, unit specific processes, and collection mechanisms. This literature review describes the existing research on these factors which supports the qualitative analysis in this thesis.

A. TEAM COMPOSITION

In 2005 *Playchess* hosted a “freestyle” chess tournament which allowed players to use computers in a team. This was a different approach to chess tournaments because the focus at the time was man vs. computer or how man could use computers to improve their game play. At the time, strong computer chess algorithms were beat by good human players aided by a standard computer; this shaped the assumption that the team with a computer aided Grandmaster would win. However, the *Playchess* freestyle tournament produced unexpected results, as a group of amateur players won. Their ability to coach several computers in playing chess, compared to using the computer as an informative tool proved to be more effective. The key takeaway from this event is that this signified a shift in human-machine teaming. A team with a weak human, machine, and a better process triumphed over a strong human, machine, and inferior process (Kasparov, 2017).

The Department of Defense has lived this reality since its inception, from gun fire at sea, to cybernetics in anti-aircraft artillery, to information as a warfighting function; teams within the organization have drastically changed to gain an edge over their enemies. In the Vietnam War, human-machine teams continued to be vital to military operations. In 1945, fifty military occupational specialties (MOS's) associated with ground combat made

up twenty-five percent of all enlisted personnel and in the Vietnam war, these same MOS's only made-up fourteen percent of enlisted personnel. This shift in MOS's was to provide more enlisted personnel for new technology support, such as radios, computers, and battlefield sensors. At the height of the war, the Military Assistance Command, Vietnam (MACV)—the joint military headquarters in Vietnam—received three million pages of enemy documents per month and, by 1966, half a million messages were being processed per month from entities outside of Vietnam (Van Crevald, 1985).

The technology integration at MACV fundamentally changed how command centers operated and created a higher demand for information. The military was able to change their structure to adapt to cutting edge technology of the time, which included communications tools and battlefield sensors. However, even with these improvements, MACV proved to be the weaker team described by Gary Kasparov—strong human, machine, and inferior process. The centralization of decision making created an information bottle neck and retarded decision-making timelines.

These case studies of technology-team fit are important because new technology did not automatically improve existing processes. Automated intelligence processes in battle management aids need to compliment military planners—comparable to computers in the freestyle chess tournament. Moreover, introducing technology without consideration for human and computer strengths may degrade productivity and increase requirements on personnel, as was seen with MACV.

B. JOINT MILITARY PLANNING

The overarching document for military planning is *Joint Publication 5, Joint Planning*. It provides a structure for interservice planning, as well as frameworks for planning with multi-national forces. This process is important for commanders, planners, and subordinates because this is how the ways, means, and ends are communicated for a military operation (DOD, 2020). In this planning framework, there are seven steps. Figure 1 lists the seven steps, and the associated staff actions of everyone involved in the process; the majority of the input from the intelligence section occurs at the beginning of the planning process. Figure 1 shows that the Joint Intelligence Preparation of the Operational

Environment (JIPOE) is introduced between planning initiation and mission analysis and supports the staff estimates. The core output the intelligence section produces in this process is the intelligence annex to an order, Annex B—intelligence estimates (see Table 1); targeting data; intelligence for each discipline; priority intelligence requirements; and intelligence, surveillance, and reconnaissance plans.

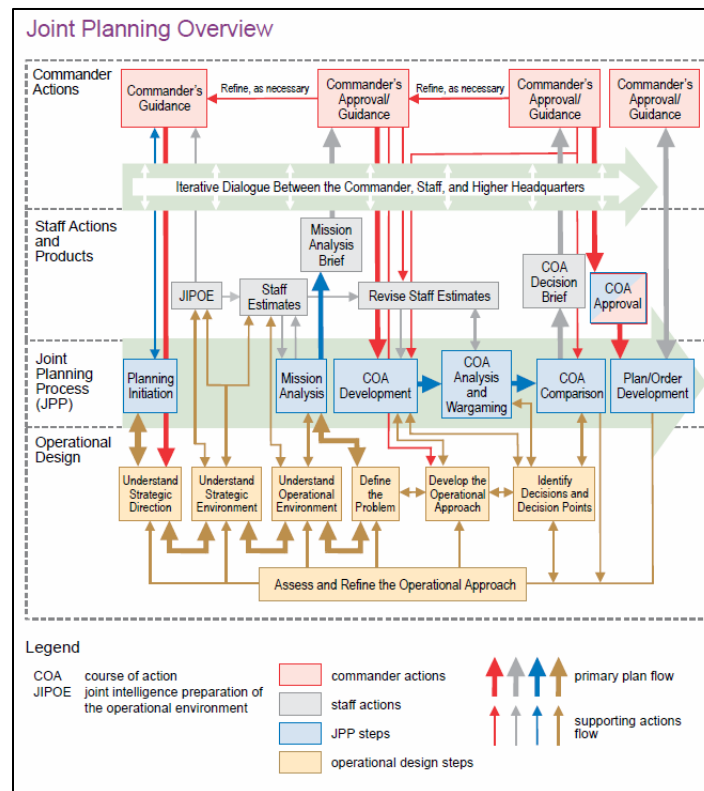


Figure 1. Joint Planning Process Overview. Source: DOD (2020).

C. MILITARY PLANNING AND INTELLIGENCE SUPPORT

The Marine Corps Planning Process (MCP) is a six-step process—problem framing, course of action (COA) development, COA war game, COA comparison and decision, orders development, transition—which the Marine Corps uses to support the Joint Planning Process (USMC, 2020). Similar to the Joint Planning Process, intelligence products are required early in the process to orient the planning team. A key input into the

problem framing phase of the MCPP is the intelligence preparation of the battlespace (IPB); the details of this document are discussed later.

Table 1. Annex B Appendices by Title. Source: USMC (2020).

Appendix	Title
B-1	Priority Intelligence Requirements
B-2	Signals Intelligence
B-3	Counterintelligence
B-4	Targeting Intelligence
B-5	Human Resource Intelligence
B-6	Intelligence Support to Operations in the Information Environment
B-7	Imagery Intelligence
B-8	Measurement and Signature Intelligence
B-9	Captured Enemy Equipment
B-10	National Intelligence Support Team
B-11	Intelligence Estimate
B-12	Intelligence Products
B-13	Intelligence Collection Plan
B-14	Reconnaissance and Surveillance Plan
B-15	Geographic Intelligence
B-16	Intelligence Operations
B-17	Support to Survival, Evasion, Resistance, and Escape

New or updated intelligence products are introduced in each step of the process and then are added to the IPB. Throughout the process the appendices to Annex B are developed to support the staff in the planning cycle. The final product, which captures all the intelligence products produced throughout the planning process, is the decision support

template and matrix. Table 2 is a list of inputs required from the supporting intelligence section for each planning phase.

Table 2. Intelligence Requirements for Each Planning Phase. Adapted from USMC (2020).

Overlays, Templates, Matrices, Worksheets, and Graphics and Narratives	Problem Framing	COA Development	COA War Game	COA Comparison and Decision	Order Development	Transition
IPB Integration	x	x	x	x	x	x
Modified combined obstacle overlay	x	x	x		x	x
Adversary template	x	x	x			
Situation template	x	x	x		x	x
Event template	x	x	x			
Event matrix	x	x	x			
Decision support template			x	x	x	x
Decision support matrix			x	x	x	x
COA graphic and narrative		x	x	x	x	
Synchronization matrix		x	x	x	x	x
COA war game worksheet			x	x	x	
Comparison and decision matrix with comments				x		
OPORD assignment matrix	x	x	x	x	x	
Liaison plan	x				x	
Planning and execution timeline	x	x	x	x	x	x

Joint Publication 2-01.3 (DOD, 2014) provides a framework for intelligence production and analysis in support of operational planning efforts. This process is a sub-component of the joint intelligence process which is displayed in Figure 2. Each service has complimentary publications that are tailored to support their warfighting responsibilities.

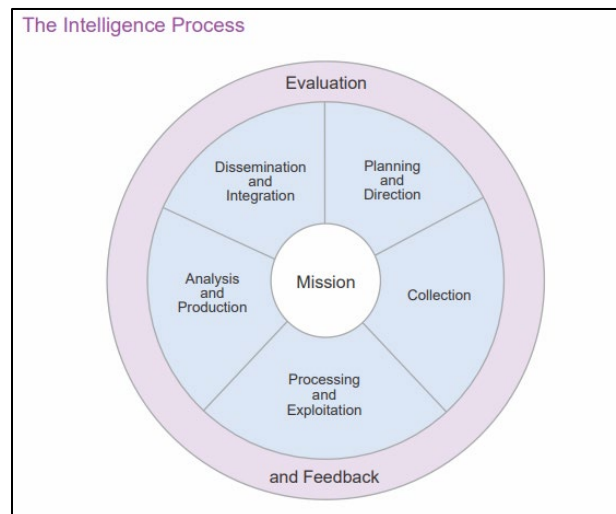


Figure 2. The Intelligence Process. Source: DOD (2022).

1. Intelligence Cycle and Knowledge

Joint Publication 2 is the overarching doctrinal intelligence publication for all the services. Like the planning publication, each service has their respective versions. However, the processes are equivalent, with planning through dissemination phases as shown in Figure 2. For the Marine Corps, *Marine Corps Warfighting Publication 2-10* (2021) captures the intent of the intelligence process, shown in Figure 3, which is to convert data and information into knowledge that enables a military decision.

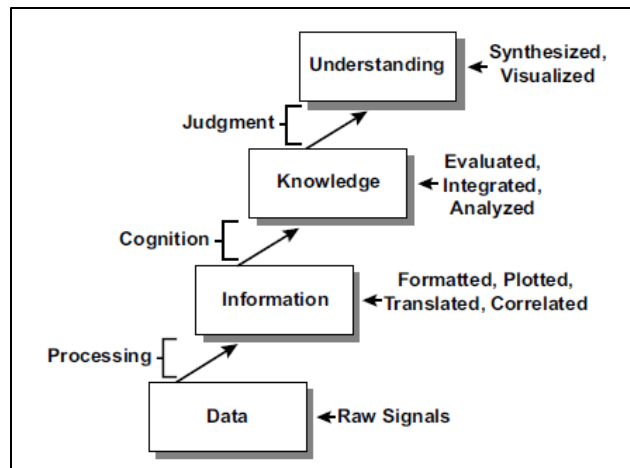


Figure 3. The Information Hierarchy. Source: USMC (2003).

Figure 3 represents the information hierarchy. The goal of an intelligence section is to ingest data collected from the operational environment, add contextual value, and provide it to the right decision maker while ensuring the information is timely and relevant. The value added from the intelligence section is not in presenting data from sensors, it is providing the “so what” of each data point by going through the processing, exploitation, and dissemination (PED) cycle. The hierarchy is important because an advanced planning aid needs to help decision makers convert data from sensors into knowledge quickly.

Additionally, the knowledge of the planners needs to transition down the hierarchy into a planning system. Knowledge is transformed into information by articulating, verbalizing, and providing structure. Then information is turned into data by a fixed representation and interpretation. This process is important in information technology because tacit knowledge is applied to explicit knowledge gained from the technology, creating more knowledge. Furthermore, the product of the combination of these knowledge categories can then be shared with a group which taps into “accumulated stocks of knowledge” (Tuomi, 2000). Then the new understanding must be put back into the technology as previously mentioned.

2. Joint Intelligence Preparation of the Operational Environment (JIPOE) Process

The JIPOE process is shown in Figure 4. “The goal of this process is to develop a holistic view of the operational environment” and to fuse operational environment and adversary analysis to create enemy assessments (DOD, 2014).

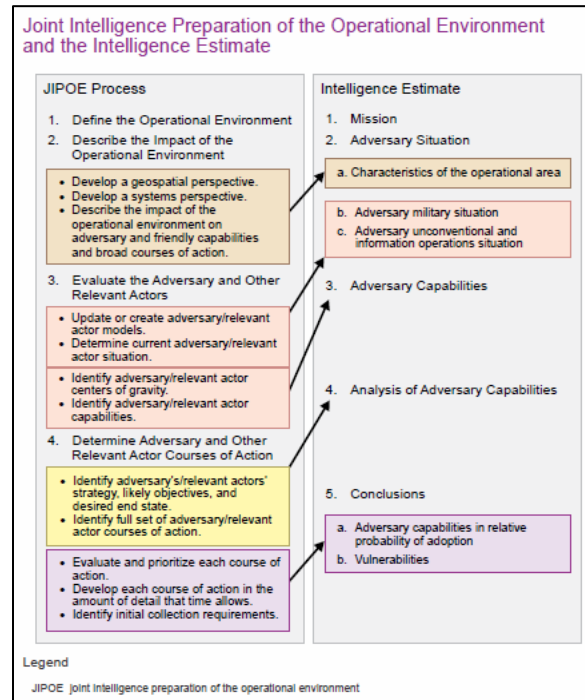


Figure 4. JIPOE Steps. Source: DOD (2014).

The adversary analysis is based on threat models that are developed in the *Evaluate the Adversary and Other Relevant Actors* phase. The model should capture the enemy's doctrinal way of fighting and how that is adapted in each situation. The model supports the development of a situation template with an adversary COA. The considerations presented in this publication are high-level because the detailed considerations are found in the service specific publications, which is visually depicted in Figure 5.

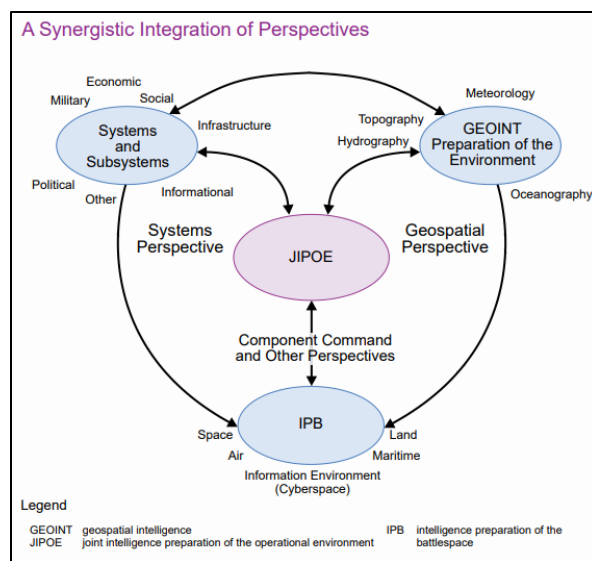


Figure 5. A Synergistic Integration of Perspectives. Source: DOD (2014).

3. Marine Corps and Army Intelligence Planning Process

The Marine Corps and Army share an intelligence publication, which is *Army Tactical Publication 2–01.3* and *Marine Corps Reference Publication 2–10B.1*. The steps in the process are *Define the Operational Environment*, *Describe the Effects on Operations*, *Evaluate the Adversary*, and *Adversary Courses of Action*.

This publication has three classifications of adversary models: *regular*, *irregular*, and *hybrid*. Regular adversary forces are militaries of nation-states employing “recognized military capabilities and forces in the understood forms of military competition and conflict (DOD, 2014).” Irregular adversary forces employ unconventional and asymmetric warfare methods. These types of forces are often weaker belligerents that need to take this approach to counter advantages of larger militaries. Hybrid adversary forces use characteristics of regular and irregular adversaries to achieve mutually benefitting effects. The output of this process is the same as the JIPOE but much more detailed.

The publication provides eleven broad areas to evaluate an adversary for the three models previously described. The broad categories are composition, disposition, strength, combat effectiveness, doctrine and tactics, support and relationships, electronic technical data, capabilities and limitations, current operations, historical data, and miscellaneous

data. The publication describes key considerations for each of the categories for a military staff for proper evaluation. However, the publication does not provide evaluation criteria to develop quantifiable metrics. Currently, this process relies heavily on sound military judgement and a firm understanding of the threat to build an accurate model.

4. Navy Process

The Navy Intelligence Preparation of the Operational Environment process has four steps that support maritime domain awareness. These are the same steps as the JIPOE and IPB processes, which is displayed in Figure 6. The major difference is the functional and domain focus of the process compared to the other services, which is why the JIPOE is dependent upon the service component intelligence processes.



Figure 6. Navy Intelligence Preparation of the Operational Environment.
Source: U.S. Navy (2014).

5. Creating an Adversary Course of Action

In layman's terms, an adversary COA is an educated guess on what the adversary is trying to achieve, how they will do it, where it will be done, and what time the actions

will take place. Fundamentally, an adversary COA is conjecture that supports decisions and focuses the other warfighting functions. The JIPOE process provides a framework to systematically reduce information gaps, which reduces conjecture, leading to a better forecast on adversary activity. Figure 7 displays most of the considerations in the operational environment which are all examined when developing an adversary COA.

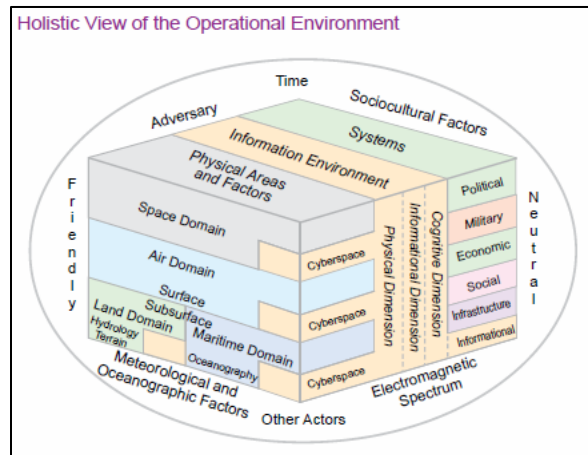


Figure 7. Holistic View of the Operational Environment. Source: DOD (2014).

Each of these inputs in Figure 7 do not mean much by themselves, but once aggregated can represent an accurate picture of the operational environment. A layer below these operational views are the intelligence disciplines which are fused together to provide an all-source intelligence perspective. This all-source lens helps develop the perspectives displayed in Figure 8.

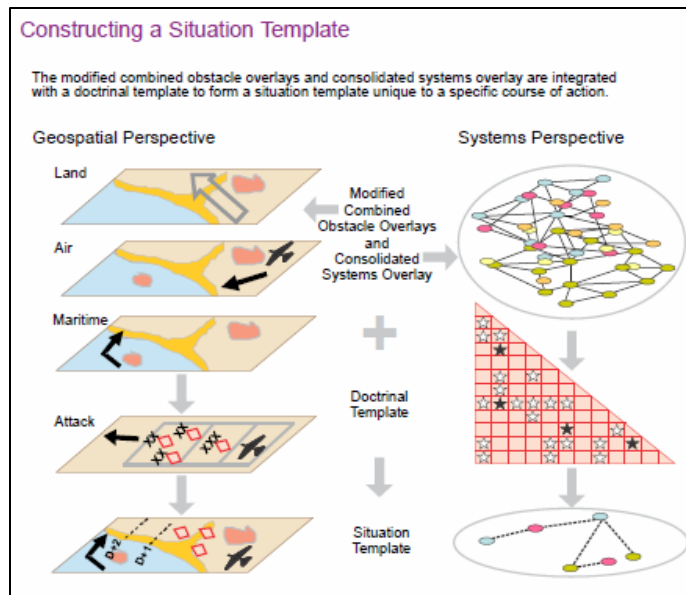


Figure 8. Constructing a Situation Template. Source: DOD (2014).

Each warfare domain is analyzed to represent the entirety of the operational environment. Then this understanding is compared to the adversary's doctrinal way of warfighting to help inform the situation template forecast. Steps two and three of the JIPOE process are designed to reduce as much uncertainty as possible in both their methodology of warfare and in the current state of the operational environment. Both factors are salient in developing an accurate adversary COA—the analyst needs an accurate starting point and to understand the preferred approach. The next step is to develop COAs and an event template, which is shown in Figure 9.

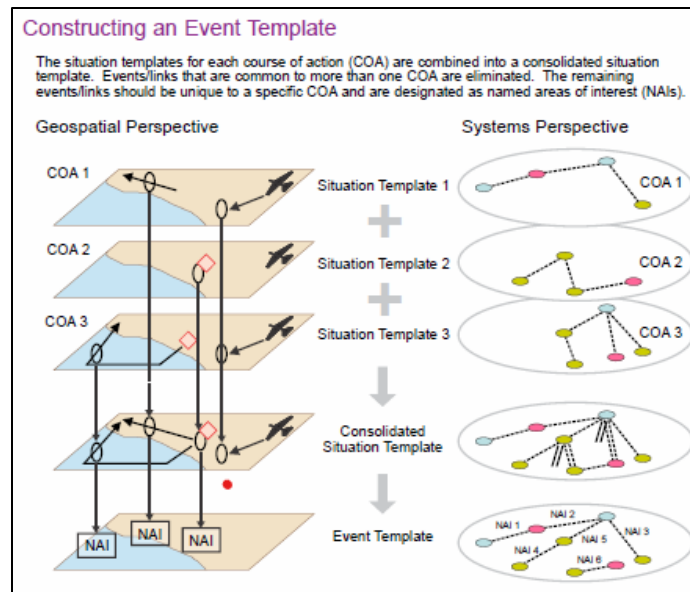


Figure 9. Constructing an Event Template. Source: DOD (2014).

The supporting intelligence section explores all the possible options or the adversary with respect to the planning timeline. Each COA is then evaluated by the following criteria:

- **Suitability.** An adversary COA must have the potential to achieve the adversary's likely objective or attain the desired end state.
- **Feasibility.** The adversary must have sufficient time, space, and resources to successfully execute the COA. However, a COA should not be assessed as unfeasible until all actions the adversary may take to overcome resource shortfalls are considered. Actions and reactions between the adversary and all relevant actors in the OE [operational environment] may help to better determine feasibility.
- **Acceptability.** The amount of risk associated with the COA should not exceed the level of risk acceptable to the adversary. The JIPOE analyst should determine the adversary's level of risk acceptance by analyzing past adversary military activity, current OB [order of battle] factors, interactions amongst relevant actors, and the psychological profiles of adversary leaders. In some instances, however, an opponent may be willing to tolerate a higher level of risk than normal, particularly if a risky COA is the only means of accomplishing the objective.
- **Uniqueness.** Each adversary COA must be significantly different from the others; otherwise, it should be considered a variation rather than a distinct COA. Factors contributing to the uniqueness of a COA may

include its effect on the friendly COA, use of reserves, location of the main effort, scheme of maneuver, or task organization.

- **Consistency with Adversary Doctrine or Actors' Patterns of Operation.** The COA should be consistent with the adversary's doctrine, TTP [techniques, tactics, and procedures], and observed practices. However, caution should be taken to guard against an adversary's attempt to achieve surprise by deliberately deviating from known doctrine or previously observed practices. The JIPOE analyst must ensure agendas from all relevant actors are accounted for as those actors other than the adversary may interact with the adversaries and shape their doctrine or patterns of operation. Additionally, the availability of new technology or desperation may also drive an adversary and other actors to deviate from past doctrine or previous patterns of operation. The challenge to the JIPOE analyst is to anticipate such changes. Red cell threat emulation and command red team alternative assessments can help to accurately reflect adversary patterns of operation. (DOD, 2014)

After being evaluated by these criteria, the remaining COAs are then consolidated to create the event template to focus collection efforts. Events that fall outside of the COAs can be marked as branches or sequels. A branch is a contingency option built into a plan to preemptively adapt to changes in the environment, and a sequel is a follow-on operation based on the possible outcomes of the current COA (USMC, 2020). Named Areas of Interest (NAIs) are then created to collect on adversary decision points that distinguish between COAs, branches, and sequels.

6. Communicating Uncertainty

Intelligence Community Directive (ICD) 203 (Office of the Director of National Intelligence, 2015) is an analytic standard governing document for the Intelligence Community, which includes each of the services. This document is important because it “established the IC Analytic Standards that govern the production and evaluation of analytic products; articulates the responsibility of intelligence analysts to strive for excellence, integrity, and rigor in their analytic thinking and work practices; and delineates the role of the Office of the Director of National Intelligence (ODNI) Analytic Ombuds” (ODNI, 2015).

More specifically, this document establishes the lexicon for communicating levels of uncertainty in intelligence products; Table 3 displays the terms and its associated

percentages. The intent is to capture what makes an intelligence assessment uncertain and to what degree. It is extremely challenging to convey uncertainty because of its relativity, but, nonetheless, this is an attempt to provide structure in knowledge gaps. Military intelligence planners and analysts use intelligence community standards for product development, but it is important to note that military analysts work for military commanders. This is important because a military commander can establish his own means of communicating uncertainty.

Table 3. ICD 203 Expressions of Likelihood/Probability. Source: ODNI (2015).

almost no chance	very unlikely	unlikely	roughly even chance	likely	very likely	almost certain(ly)
remote	highly improbable	improbable (improbably)	roughly even odds	probable (probably)	highly probable	nearly certain
01-05%	05-20%	20-45%	45-55%	55-80%	80-95%	95-99%

Transitioning to application, in the March-April 2019 edition of *Military Review*, Army University Press, the article *Thriving in Uncertainty, From Predictive- to Probability-Based Assessments* (Adamski & Pence, 2019) was published. The principal idea is that intelligence professionals should use probability-based assessments rather than the traditional enemy most likely course of action (EMLCOA) and enemy most dangerous course of action (EMDCOA). The traditional use of an EMLCOA and EMDCOA is usually static and only accounts for two possible futures.

A five-step process was proposed: (1) Understand the Relevant Range of Possible Events, (2) Plot the Range of Events, (3) Focus Attention on Most Likely and Relevant Events, (4) Identify Branch Plans and Adjustment Decisions, and (5) Use the Multi-Horizon Event Template. Developing the range of possible events is generated through brainstorming and through analysis of the battlespace. These events are then assigned a probability by the planning group and plotted on cartesian coordinates. The further the curve is skewed to the right, the more dangerous the battlespace; an example of events plotted on a normal distribution is represented in Figure10.

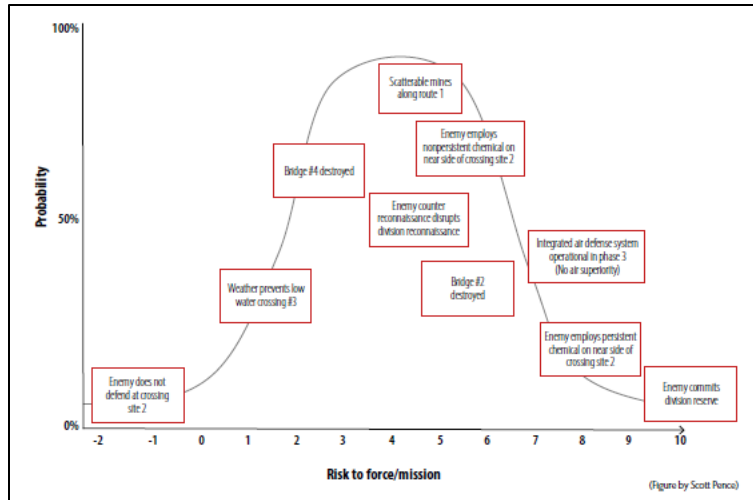


Figure 10. Events Plotted along a Probability Curve. Source: Adamski & Pence (2019).

The next step is to draw vertical lines on the graph that places boundaries on the most likely events. This supports developing an enemy COA while addressing the other possibilities in the tasks or coordinating instructions portions of an order. After identifying the mostly likely events, branch plans are identified which include unlikely events. Finally, the multi-horizon event template is produced which is the final product of this process, displayed in Figure 11. This is directly relevant to intelligence processes supporting all warfighting functions. Fundamentally, this is what advanced planning aids are trying to achieve on a much larger scale.

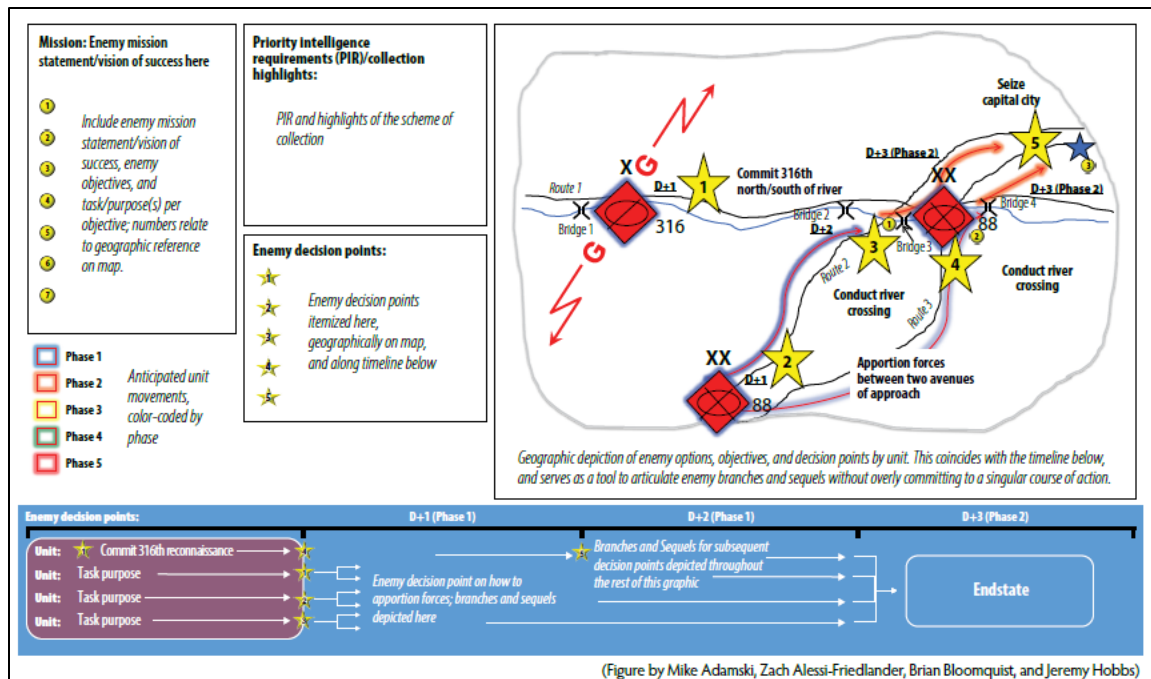


Figure 11. Multi-Horizon Event Template. Source: Adamski & Pence (2019).

D. DECISION MAKING THEORIES

Intelligence planners supporting the planning process are forced to make hundreds of small, but crucial, decisions about what the adversary might do, based on sets of overwhelming data, most of which possess uncertainty. What follows are methods and considerations about decision making that support bounding and minimizing uncertainty in decisions.

1. Naturalistic Decision Making

“Metarecognition is a cluster of skills that support and go beyond the recognitional processes in a situation assessment” (Zsombok & Klein, 1997). It provides a logical framework of testing and evaluating an individual’s mental model of an observable event. Using this framework, an individual develops recognitional schemas, critiques them, and then corrects the mental model. This process can result in identifying three types of problems in an assessment: incompleteness, unreliability, or conflict.

According to Cohen, Freeman, and Thompson (1997), military members with metarecognition training considered more factors in making decisions. Moreover, trained

individuals also were less likely to consider irrelevant decision parameters than their traditional situational assessment technique trained counterparts. This increase in decision factors did not impact the quality of the decision made by the participants; instead, the decision made by the metarecognition trained participants were deemed to be higher quality than the traditionally trained participants.

The metarecognition training challenged the participants' way of handling uncertainty in decision making. The training began with asking the participants to describe a personal experience that they were completely certain in their assessment. The trainer would then show that their feeling of certainty could be questioned. The questioning of their certainty forced the participants to explore an alternative story that covered all the evidence. This exposed their assumptions underlying their certainty, which could then be evaluated. If the participant still believed in their story, then the confidence in the story was well earned.

The process is captured in four steps: (1) select a critical assessment, (2) imagine that a perfect intelligence source tells you this assessment is wrong, (3) explain how this could be wrong, and (4) then the intelligence source tells you that you are wrong again and to go back a step. The end state is to identify all the existing assumptions and their validity. This process is important to advanced planning aids because it helps validate assumptions or uncovers unknown factors in the environment.

2. Level of Automation

Dr. Mica Endsley and David Kaber (1999) analyzed how computer automation can support human decision making. Their research found that when human generated options are supported by computer decision analysis, the implementation produced superior performance. The research focused on replicating a situation, like piloting or air traffic control, where the operator was required to avoid object collision, located objects, and process tasks. The simulation presented multiple targets to the participant as boxes moving at various speeds towards a center point and the participant's goal was to select each box and eliminate it.

An interesting finding in the simulation was that performance deteriorated when a computer provided guidance to participants regarding option selection, but proved to be very successful when simply presenting information to the participant. When provided computer guidance, the operators became distracted from the task because they second guessed their own choices and focused on new information rather than task performance. This research proved that there are optimal roles for computers and humans in a system and that technology should be leveraged for high performance, therefore, leading to a better performing system. It is important to note that the test subjects of this research were college students and not trained or experienced people in their trade.

3. Expected Utility Theory and Prospect Theory

Expected Utility Theory was the dominate descriptive theory for decision making before Prospect Theory. Sebor and Cornwall (1995) concur with the findings of Kahneman and Tversky (1979), that context is an important decision parameter and can cause a shift in preferences, which is how a player ranks a set of possible outcomes (Tadelis, 2013). Expected Utility Theory is based on three tenets, expected utility of an outcome, asset integration (measured by final states rather than gains or losses), and risk aversion. The utilities of outcomes are weighted by their probabilities of occurring, making the decision process based largely on conditional probabilities or risk (Kahneman & Tversky, 1979).

Daniel Kahneman and Amos Tversky (1979) created Prospect Theory to better explain decision making under risk which was a paradigm shift from Expected Utility Theory. The difference is that Prospect Theory says that an individual thinks in terms of expected utility relative to a reference point, instead of just the outcome. The major theme is describing loss aversion; people are more likely to take a risk if it means avoiding a loss.

Humans do not decide in absolutes or think “rationally” about the outcome because their decision is based on the perception of their current state (Kahneman & Tversky, 1979). Additionally, decisions change substantially when the situation is about a gain or a loss. Overall, humans are naturally risk averse with gains and risk seeking with losses (Kahneman & Tversky, 1979). This theory is important in intelligence planning when

forecasting future events. The intelligence analysts must understand the enemy's current state and how their military leaders interpret that state.

E. ADVERSARY MODELING

The characteristic of developing an adversary model was discussed briefly in the Marine Corps and Army Intelligence Planning section. The author of the publication provides eleven areas to evaluate in developing an adversary model. The limitation of the publication is that it does not detail how to technically represent an adversary model. The following section introduces concepts that are used to generate combat values from models and capture adversary characteristics numerically.

1. Combat Values

Army Major Joseph McCarthy (2020)—Center for Army Analysis, Combat Sample Generator Team Chief—argues that the correlation of forces and means need to start with the weapon system. By starting with the weapon system, military planners can take a building block approach and be more confident in their combat values. He then argues that older models of combat values are antiquated because they have a limited ability to account for the effects of modern weapons.

The Combat Sample Generator captures “high-order effects and implications” because of its ability to generate diverse battlefield interactions. One of the ways it captures high-order effects is by incrementally updating a units' combat value based on new equipment. One example the author provides is the introduction of a counter battery radar. The gunnery components did not improve; however, the supporting equipment improved which makes the artillery more lethal, giving it a higher combat value. An example is displayed in Figure 12.

 Sample Unit		Combat values are notional		Legacy Sample Unit	Modernized Sample Unit		
		Unit Combat Value:		1,498	1,828		
Category	Equipment	Combat Value	Legacy Quantity	Mod. Quantity	Individual Contributions Developed by CAA based on authoritative lethality and survivability data from the Army's Data Analysis Center		
	Tank	Abrams Tank	7	100	0	700	-
		Modernized Abrams Tank	9	0	100	-	900
					1		4
	IFV	Bradley Infantry Fighting Vehicle	4	100	0	400	-
		Next Generation Combat Vehicle	5	0	100	-	500
	ATGM	Javelin	2.5	40	40	100	100
	Artillery	Paladin, Self Propelled 155mm	12	10	0	120	-
		Extended Range Cannon	15	0	10	-	150
	Mortar	M121, Self Propelled 120mm Mortar	4	12	12	48	48
	Crew Served	HMMWV - Mk. 19	1	30	30	30	30
		HMMWV - .50 cal	1	30	30	30	30
	Small Arms	Small Arm	0.1	700	700	70	70

Figure 12. Combat Value Comparison Sample. Source: McCarthy (2020).

There are limitations to the Combat Sample Generator methodology. The model does not recognize when combined arms synergy is lost. For example, if tanks were replaced by artillery, it may yield a higher combat value, but the loss of the combined arms effect is lost. Additionally, the model does not account for diminishing returns. If the user adds more tanks, the model will render a higher value. This does not necessarily mean that a unit has a higher combat value, especially in congested operating environments. Overall, this model is linear and is complimentary to military planning cycles; decisions should not be made solely on this model.

The author also challenges the traditional force ratios prescribed in older Army publications. He argues that the ratios may be outdated because of modern weaponry. The employment of precision, long range weapons may change the ratios required to attack—a deviation from the traditional 3:1 ratio. Older versions of *Field Manual 6-0* have sections on force ratios; however, the most recent version of *Field Manual 6-0* (U.S. Army, 2018) does not prescribe force ratios.

2. Game Theory Applied to Time Critical Targets

Game Theory is the study of actions, outcomes, and preferences which together comprise a decision problem. This framework facilitates the development of decision space models, which can be in conflict or cooperation models, for rational decision makers. A rational decision maker is an individual that is attempting to maximize his payoff given the variables and boundaries of a situation (Tadelis, 2013).

The RAND Corporation (Hamilton & Mesic, 2004) published a document which captured the utility of game theory against time critical targets on enemy air defense. The authors generated initial values for a typical four by four matrix which assigned actions a payoff. They referred to this as measures of effectiveness and developed the best outcomes for each player. In this case, one force had striker and suppression of enemy air defense aircraft and the other force had surface to air missile systems. The outcomes represented future scenarios, based on expected responses, and how a player can achieve their best future. The authors used a two-player, zero-sum game, which is where the “interests of the players are diametrically opposed” (Hamilton & Mesic, 2004). In this type of game, one player loses while the other benefits and the sum of both players payoff equals zero (Tadelis, 2013). The zero-sum game is important because this is the approach to a military operation; simply put, one wins the battle and the other loses.

The usefulness of the Nash Equilibrium point as a planning tool is described in several examples. The equilibrium points varied substantially in each scenario; this change was due to assigned values of several factors, which included target value, probability of hit, probability of kill, and probability of detection. Figure 13 displays the calculation of an Optimum Red Strategy using the value of strike, value of aircraft, probability of kill (of surface to air missiles and anti-radiation missiles), and the value of surface to air missiles.

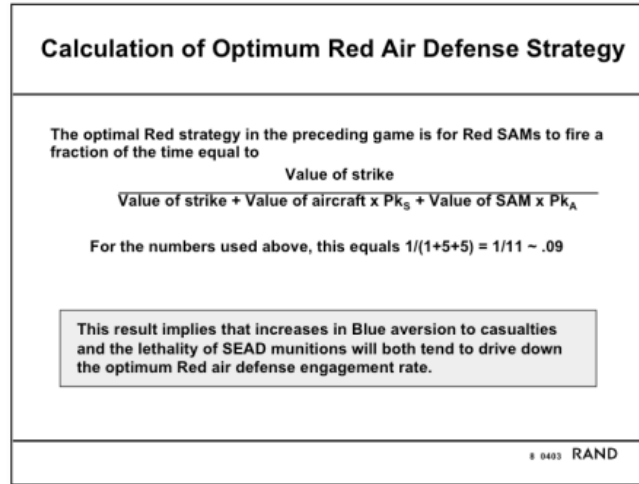


Figure 13. Calculation of Optimal Air Defense Strategy. Source: Hamilton & Mesic (2004).

These ideas are important to this thesis because they try to represent threats and their possible actions by converting information collected through the intelligence process to statistical friendly data types. Additionally, this section shows how a numerical representation of an adversary is highly subjective; the generated value scale is biased by the experiences of the creator.

3. Weighted Adversary Assessments

A study conducted by the United States Army Research Institute for the Behavioral and Social Sciences (Thompson, Landee-Thompson, Fichtl, & Adelman, 1989) developed a method for evaluating the effectiveness of military intelligence in specific situations. The intent behind this research was to employ “user-specific, situationally dependent profiles” based on the information needs hierarchy to evaluate the performance of military intelligence.

The research consisted of numerous interviews with active duty and retirees using the Multi-Attribute Utility Assessment (MAUA). The MAUA structured approach helped assess the value or utility decision-makers placed on the alternatives that were available, relative priority of the factors they deem important, and how well each alternative scores.

The overall goal of MAUA is to better understand a decision makers' subjective process and provide a means to evaluate the decision alternatives.

The researchers identified that situational context changed the results of their interviewees. This context, for example, included who was using the information, when it was being used (peace or war), where, and for what purpose. This context changed their decisions about the parameter weights. The parameter weights were created from the information hierarchy that is shown in Figure 14.

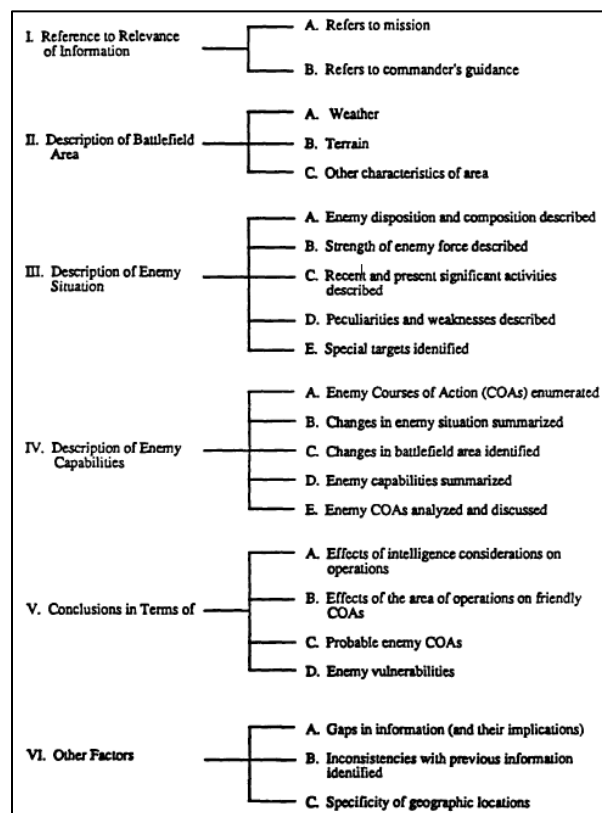


Figure 14. Planning Information Needs. Source: Thompson et al. (1989).

During the interviews, the researchers identified that information needs were not task dependent but were largely shaped by their mental models of the battlefield and their information gaps in that model. It was also identified that the importance of information categories became more important to research participants when the battlespace

transitioned from peace to wartime—the only exception to this was the importance of the political climate which was more important in peace time.

Intelligence output utility factors were created for the study to evaluate intelligence support. These factors include timeliness, currency, completeness, conciseness, clarity, graphical, accuracy, credibility, reliability, filtered/processed, interpretation, and relevance. Timeliness and currency were ranked the most important by interviewees, followed by credibility and reliability. The difference between timeliness and currency is that timeliness is about the overall output while currency is specifically about the age of the information.

The study next divided up the items in the information hierarchy and assign weights based on importance. The research found that the importance of an information item is dependent upon the role of the planner. For example, the G-3 units representative weighted “description of the enemy course of action” at fifty percent, while the G-4 representative weighted it at twenty-five percent. Moreover, the G-4 representative weighted “intelligence considerations,” which includes priority intelligence requirements, with zero percent while the G-3, G-2, and fires weighted them ten percent or higher. The weights assigned by participants changed considerably when the interviewer changed the assumptions of the operating environment from non-permissive, to permissive.

It is important to note that only four people were interviewed for the weighted information needs part of the research. Furthermore, the participants were not able to discuss the matter with others or ask for clarification. Therefore, these results are likely not representative of their warfare community.

F. LITERATURE REVIEW CONCLUSION

Each topic discussed in this chapter are interconnected. The doctrinal publications provide a starting point and common language for military intelligence professionals, but the other topics support the development of adversary assessments. The team dynamic between technology and human performance is critical to the success of the organization.

The human element uses processes and techniques, such as the JIPOE or metarecognition, to understand who they are fighting and challenge their understanding.

Then that understanding is used to develop courses of action which supports military planning cycles. Planning efforts can be further supported by converting intelligence production outputs into a ratio scale that can be used in game theory or force ratio equations. Throughout the intelligence cycle or employing these techniques, the planners are weighting input parameters to make decisions. The remainder of this thesis will explore how intelligence processes analyze information to bound uncertainty and then map that data model to advanced planning aid theory.

III. RESEARCH DESIGN

A. OVERVIEW

The literature review conducted in the previous chapter created awareness for intelligence support in military planning, human-machine considerations, contemporary experiments with intelligence models, and converting intelligence into quantifiable data. The key takeaway from the literature review is that technology can support intelligence processes and models in reducing uncertainty for military decision makers through a series of interrelated products. These processes are designed to systematically create mental models, reduce biases, and integrate data to form a holistic understanding of an area of operations. The challenge is taking the existing processes and using modern technology to perform these functions. This chapter covers the method of analysis for Chapter IV.

B. METHOD OF ANALYSIS AND SCOPE

The analysis in Chapter IV focuses on intelligence processes and how they assist in automatic adversary course of action (COA) generation in supporting a “digital planning environment” (Clary, Contreras & Hamrick, 2022). This type of environment allows operations plans to be refined through rapid modeling and simulation. This research will analyze the Intelligence Preparation of the Battlespace (IPB), how the process supports planning efforts, and how it can support a digital planning environment. From here forward, the process for analyzing adversary forces will be referred to as IPB rather than Intelligence Preparation of the Operational Environment (IPOE). When the reader sees IPB, it refers to a combined generalized process of the IPOE and IPB. The distinction between the two processes is IPB is a Marine Corps and Army term for the adversary analysis process. The other services and joint doctrine refer to this process as IPOE or Joint IPOE (JIPOE), but IPB will be used because it is very detailed and easily accessible via an open-source search.

C. IPB PROCESS OVERVIEW

“The Intelligence Preparation of the Battlespace (IPB) is the systematic, continuous process of analyzing the threat and environment in a specific geographic area” (USMC, 2014). The focus of the IPB process is forecasting an adversary COA and describing the battlespace to support the development of a friendly COA. The process consists of four steps, as shown in Figure 15.

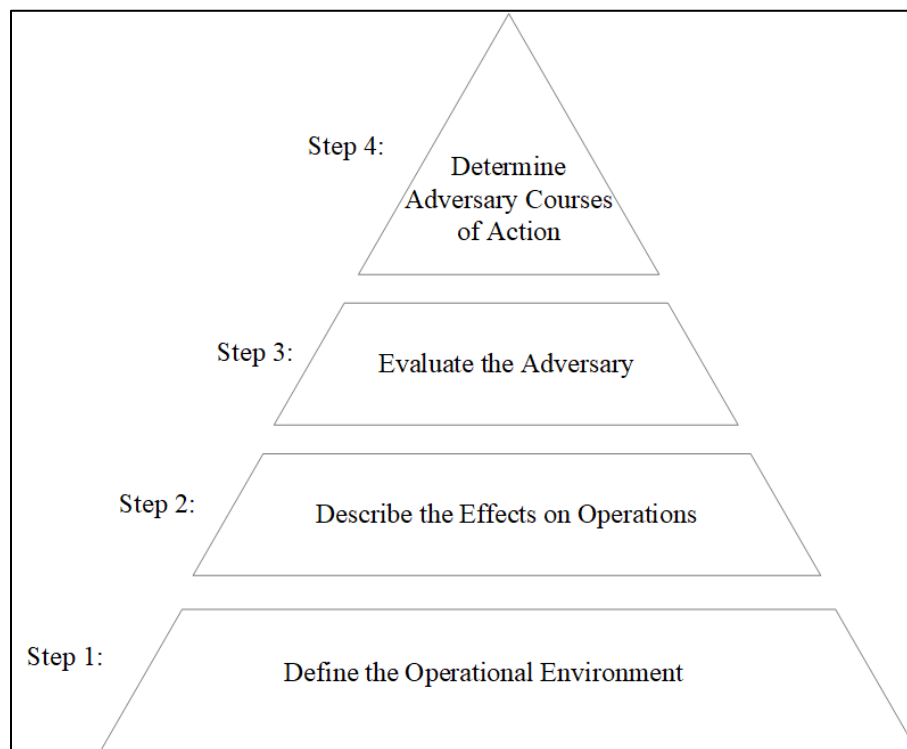


Figure 15. IPB Steps. Adapted from USMC (2014).

The steps depicted in Figure 15 are sequential and formative for the successor step. Step 1 identifies the key characteristics to focus Step 2 and builds a mental model for analysts involved in the process. Then Step 2 helps provide a detailed understanding of the battlespace with a brief introduction of the adversary. Step 3 is about building the adversary model and viewing the model through the environmental impacts. The final step brings all the information together to forecast what an adversary will do in the area of operations.

This process is considered effective in supporting planning when it achieves the following, according to the IPB publication:

- Accurately defines the commander's area of interest to focus collection and analysis on the relevant aspects of the mission variables of adversary, terrain, weather, and civil considerations.
- Describes how each of these four mission variables will affect friendly operations and how terrain, weather, and civil considerations will affect the adversary.
- Provides the IPB products necessary to aid each step of military planning in accordance with the planning timelines and guidance provided by the commander.
- Determines how the interactions of friendly forces, adversary forces, and indigenous populations affect each other to continually create outcomes that affect friendly operations. (USMC, 2014)

The intelligence products from this process must have several characteristics for it to be considered excellent intelligence; these characteristics are anticipatory, objective, complete, accurate, timely, useable, relevant, and available (U.S. Navy, 2014). Unfortunately, some of these are competing, such as timely and complete, and require deliberate tradeoffs to support planning efforts—IPB is scalable and is often tailored to support rapid planning timelines, like the Marine Corps Rapid Response Planning Process.

D. IPB AND THE PLANNING PROCESS

The output of any intelligence process is to support planning or operations, so they are closely coupled. There are deliberate inputs and outputs from each process that help focus intelligence efforts and reduce uncertainty for planners. Figure 16 displays the inputs and outputs for the Marine Corps Planning Process (MCP) and the Military Decision-Making Process (MDMP). The letters in *italics* are for MCP and the standard letters are for MDMP.

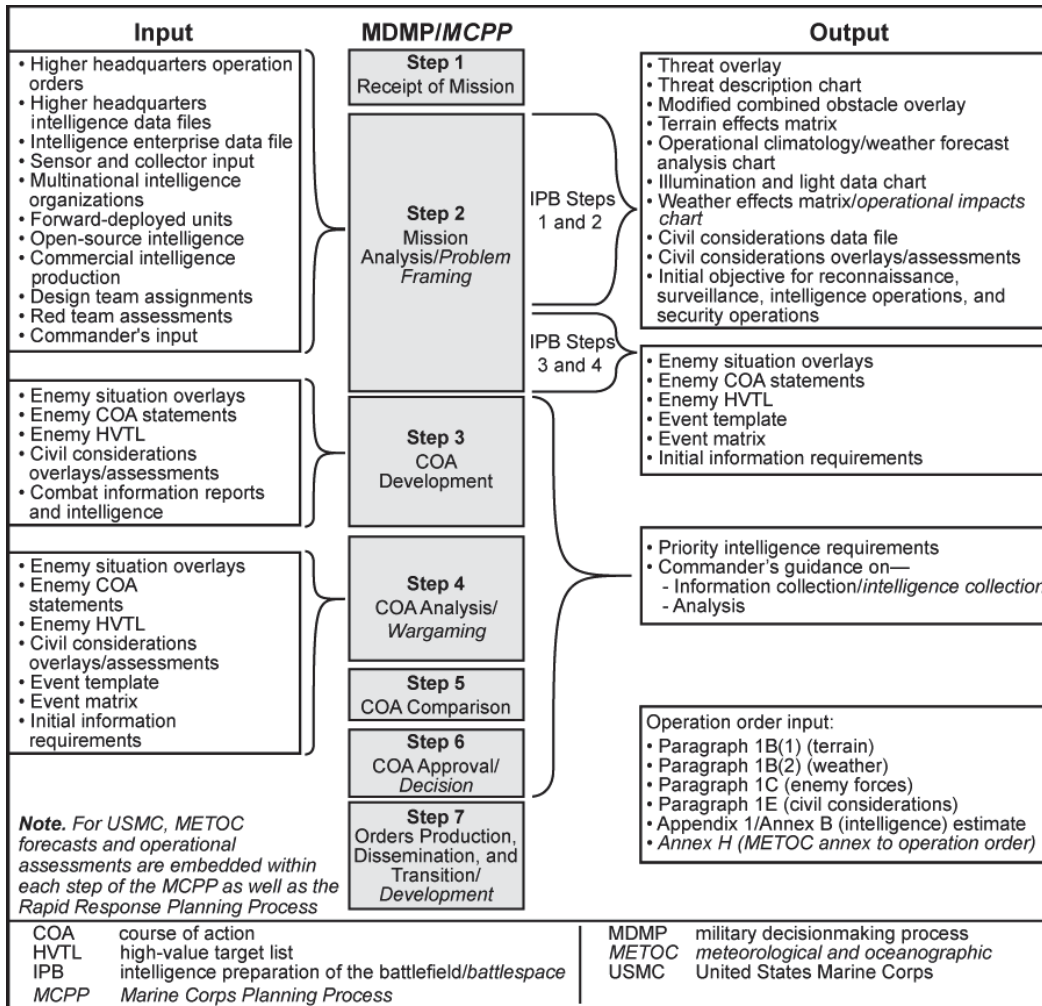


Figure 16. Marine Corps Planning Process and the Military Decision-Making Process. Source: USMC (2020).

It is important that intelligence planners complete this process prior to COA development, a planning phase, which is displayed in Figure 16. The friendly COA needs the outputs from each of the IPB steps to make informed decisions, recommendations, and to reduce uncertainty. There are four general areas of uncertainty in the IPB process: enemy, civil, weather, and terrain considerations. Each step is designed to reduce uncertainty in one or all these areas; in doing so, the supporting intelligence personnel are shrinking the possible future states for an adversary in the battlespace; visual representation of this is depicted in Figure 17.

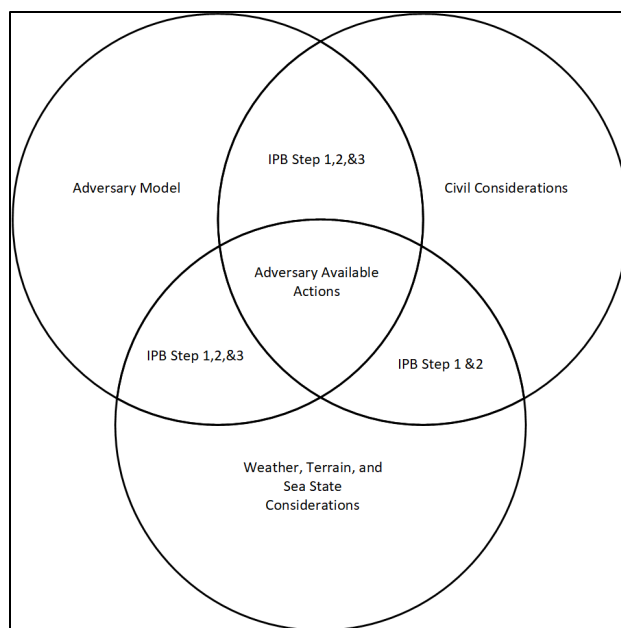


Figure 17. IPB Information Relationships. Adapted from USMC (2014).

The possible adversary actions and objectives are in the center portion of the Venn Diagram shown in Figure 17. All future adversary states in an operating area are captured in the center. Analyzing weather, terrain, sea states, and civilian factors reduces the space available for adversary and friendly actions and guides friendly COA generation. For example, high winds and mountainous terrain may limit a maneuver element to ground transport on roads. This would eliminate possibilities for friendly actions in areas off roads and modes of transportation that are vulnerable to high winds, such as aircraft. Although this is a simple example, it represents how available actions in the battlespace are reduced through this process. It is also likely to expose unknown available operating space—like an underground tunnel network—that may add to the possible future states.

Reducing uncertainty is important, but it must be a focused effort. All intelligence efforts must support friendly operations, period; intelligence production for intelligence personnel is a waste of resources. IPB efforts must support developing knowledge; situation development; support to dynamic and deliberate targeting; risk management; and intelligence, surveillance, and reconnaissance allocation (USMC, 2014). Each step of the IPB process should be created with the intent of logically connecting key intelligence

questions to the supported operations functions and with information requirements of planners.

E. THE AUTOMATED WHITE CELL STRUCTURE

Each product in the four phases of the IPB process will be mapped to an event-verb-event (EVE) in an EVE chain. The EVE structure is a theoretical construct developed by the Naval Air Systems Command, Naval Air Warfare Center, Weapons Division for creating COAs in a decision aid known as The Automated White Cell (TAWC). TAWC uses artificial intelligence and machine learning with game theory techniques to generate COAs that will adjudicate competing forces in achieving their objectives and end states (Nagy, 2020). Table 4 displays the key vocabulary terms for an EVE structure as defined by Nagy.

Table 4. EVE Key Vocabulary. Source: Nagy (2020).

Word	Definition
Event	All or part of a world state at a specific timeframe – the world state consists of all enabler and influencer state variables involved with game play. In this TAWC construct, events consume no time during game play.
Verb	An action available to the Enabler and Influencer Entity that changes the world state and consumes time on the game board.
Enabler	An asset, a “piece” within the game, that has specific Verbs (or actions) that when performed can affect the world state, e.g., Entity enabler Verbs can counter the negative effects of entity influencer actions and counter obstructions; or Enabler Verbs can take advantage of an obstruction that supports mission success. Note: Depending on perspective, Enablers can be blue or red game pieces. Enablers are only represented by Entities.
Influencer	There are environmental and entity influencers. Environmental influencers consist of moveable and immovable obstructions, as well as weather conditions above and below. Entity influencers have Verbs that when performed can negatively affect one or more Enabler Entity state variables, as well as moveable obstacles in a way that causes mission failure. Note: Depending on perspective, Influencer Entities can be blue or red game pieces.
Predecessor Event	Specific attributes within a world state that are needed for an Entity’s Verb to be used.
Successor Event	Specific attributes within a world state that resulted from one or more Entities using Verbs.

Each of these words in the EVE vocabulary have synonyms in military planning. An event is a snapshot of the common operational picture (COP) for both enemy and friendly units. A verb is a tactical task that takes a unit from an existing state, normally defined by a COP, to the desired state or COP. The enablers are mission support assets that assist the tasked unit in achieving their transition in states. Tasks and units can be obstructed by influencers, which are environmental or human generated planning factors in an operating area. Finally, the predecessor events are condition-based statements used in military tasking and the successor event is the new state after the task is performed. A generalized mapping of planning, the IPB processes, and the EVE construct is displayed in Figure 18.

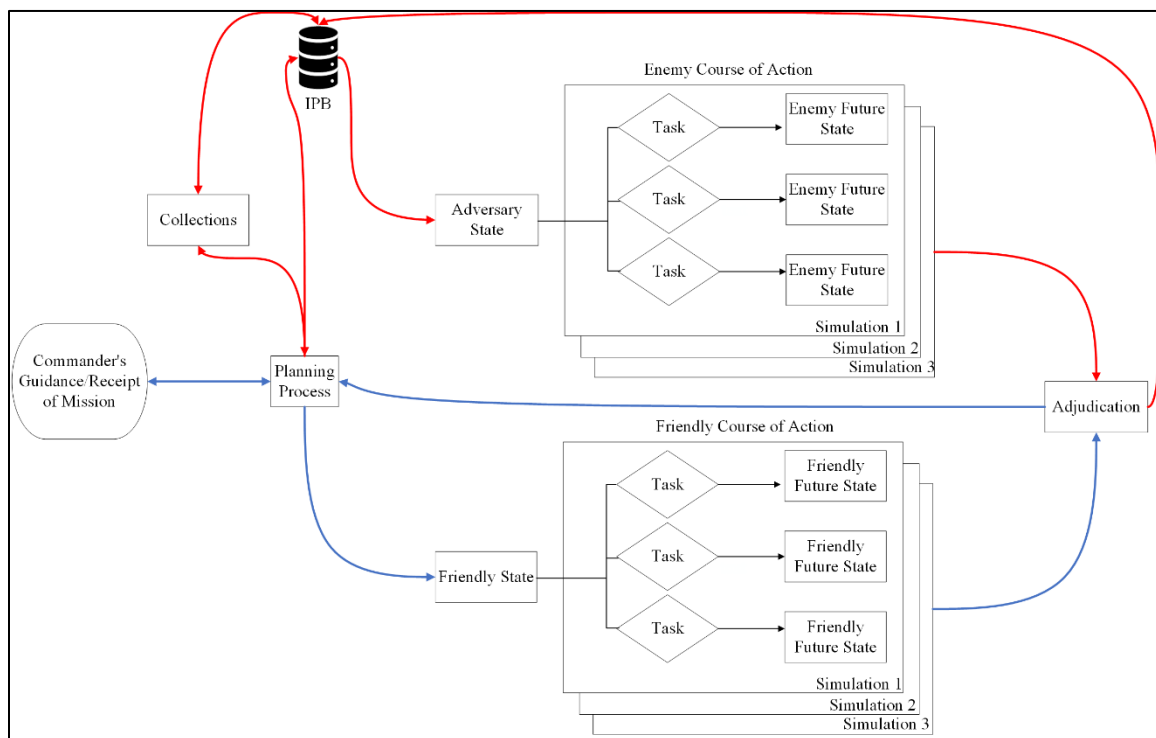


Figure 18. Planning Process Mapped to the EVE Structure. Adapted from Nagy (2020).

The events and verbs required for this construct to be effective require intelligence processes to identify what verbs are preferred, or required, by an adversarial force and a typical sequence of tasks. The next chapter will examine how existing processes support

the EVE structure and how to delineate between data and intelligence products. The relationship between intelligence products and data is important to document to generate accurate threat simulations and develop conditional probabilities through EVE construction. The method for analyzing these factors is to map the intelligence inputs and outputs with EVE modeling considerations. This approach will link the relationships between data, intelligence products, and processes which is the first step in developing threat models for advanced planning algorithms.

F. SCOPE

For scope considerations, products and processes that are not publicly available will not be included in this thesis. Producing an unclassified document will make converging the findings from this research into other research easier. Additionally, the technical details of intelligence collection are out of scope; the focus will be on all-source products that have already fused raw data and how they support adversary COA generation.

Special use cases are not the target for this research. The doctrinal publications for each service have sections regarding support for events like humanitarian assistance, disaster relief, non-combatant evacuation operation, etc. Conventional warfare is the focal point for this thesis and tailored approaches for specific events will be proposed in future research.

G. CHAPTER SUMMARY

This chapter described the method of analysis used in the next chapter. Intelligence requirements in a conventional war scenario will be the focus of the remaining text. Uncertainty can spoil planning efforts and the utility of data analysis methods; the next chapter is an attempt to combine leading theories and doctrine to provide a methodical framework that will reduce unknowns in planning. Although the general framework for TAWC has been designed, the program has not been developed. The TAWC structure is used in this research as an example of an advanced planning tool, but the results are generalizable—this is based on the assumption that most advanced planning aids would provide similar capabilities based on the same information.

IV. ANALYSIS AND OBSERVATIONS

A. INTRODUCTION

Effective processes are vital to the success of large organizations, including the military. This is, and should be, a key focus area for military operations centers. Forward units in an operation provide real warfighting capability. “Real” warfighting capability meaning these are the units engaged in the fighting. The higher an operations center is on the command relationship diagram, the further they are removed from bayonets or harpoons; their fight is planning, resource allocation, and staff processes.

These processes include planning, logistical needs, targeting, and intelligence support. This chapter is focused on mapping doctrinal intelligence processes to the Event-Verb-Event (EVE) structure to make these processes faster and the outputs more precise to better support tactical units. Creating advanced planning aids without consideration for doctrinal processes is a fatal mistake; it is imperative that military doctrine is used to develop supporting technology. Most of the following information is derived from *Marine Corps Reference Publication 2-10B.1* (2014), with supporting literature pulled from other doctrinal material.

The rest of this chapter analyzes each specific process steps of the IPB, seeking the inputs, outputs, information flows, and key products that would inform the EVE structures. The EVE structures are crucial, because they are used to construct feasible enemy COAs (EVEs are also used to create friendly COAs, but that is beyond the scope of this thesis). The more informed the enemy COAs, the less uncertainty planners must address.

B. IPB ANALYSIS

Step 1 of the IPB process is Define the Operational Environment and is designed to identify areas for further analysis in the subsequent steps. Guidance from higher headquarters and the unit commander is provided to the command staff and it requires validation, such as Area of Operations (AO), Area of Influence (AoInf), and Area of Interest (AOI) boundaries. Figure 19 displays the inputs and outputs of Step 1.

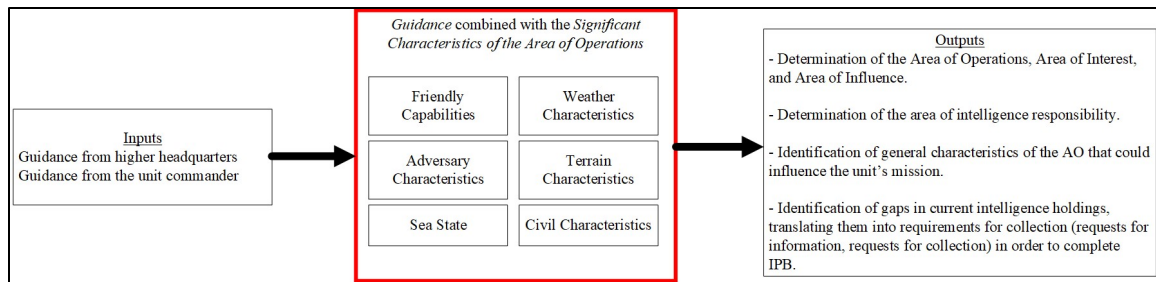


Figure 19. Step 1 Inputs and Outputs. Adapted from USMC (2014).

The inputs into this process are guidance from higher headquarters and the guidance from the unit commander. The union of the guidance provided, and the Significant Characteristics of the AO, help identify the areas for future analysis and begin to form mental models for the planners. The outputs confirm the battlespace framework, define the characteristics just mentioned, and identify gaps in information. Table 5 represents the elements in each characteristic.

Table 5. Information Requirements for Each Characteristic. Adapted from USMC (2014).

Adversary	Terrain	Weather	Civil Considerations
Identity	Obstacles	Visibility	Areas
Location	Avenues of Approach	Wind	Structures
Size	Key Terrain	Precipitation	Capabilities
Disposition	Observation and Fields of Fire	Cloud Ceiling	Organizations
	Cover and Concealment	Temperature	People
		Humidity	Events
		Sea State	
		Thermal Crossover	
		Atmospheric Pressure	
		Solar Activity	

Adversary Characteristics is composed of the following information: identity, location, size, disposition. Another example is *Terrain Characteristics*, which is comprised of obstacles, avenues of approach, key terrain, observation and fields of fire, cover and concealment, the rest of the table also takes this form. Each one of the elements listed in Table 5 can be decomposed further for more precision; for example, wind can be reduced to many sub-elements like direction and speed.

The completion of Step 1 initiates the beginning of Step 2, which requires the validated commander's guidance and a focused search that was created in Step 1. The information required for Step 2 is mostly the same but much more detail is required. The approach in Step 1 is discovery, where Step 2 is mapping the data to effects on operations. Figure 20 represents how the information inputs discussed in the previous step belong to intelligence products, such as the *Military Aspects of Terrain* analysis feeds the *Terrain Effects Matrix*.

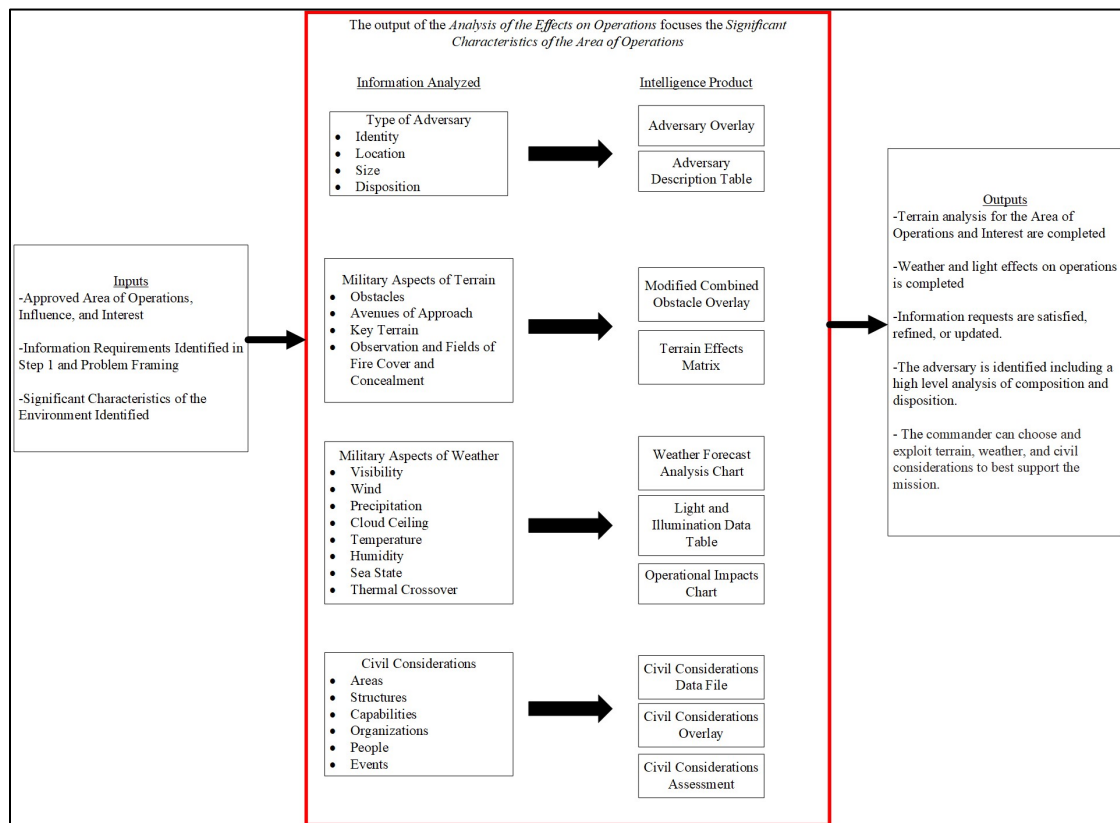


Figure 20. Step 2 Inputs and Outputs. Adapted from USMC (2014).

As shown in Figure 20, the Step 1 outputs help focus information gathering and analysis in Step 2. The information under *Information Analyzed* in Figure 20 represents the required inputs for the intelligence products on the right side of the arrow. Each information category is also broken down further into more specific categories, which are displayed as bullet points. The information collected in each of these categories informs the intelligence product and overall output, shown in Figure 20. These products are needed because they display battlespace effects in a standardized way and provide a helpful visual representation of the data. Moreover, they are foundational for adversary COA development and required planning inputs for friendly COA generation.

This step is not simply an aggregation of data; there is an important human contribution in this analysis. The intelligence analyst building the intelligence product combines explicit and tacit knowledge in this analytical process. Much of the battlespace effects are captured in manuals, but there is an experience component that is invaluable. An analyst with years of experience in a given area might produce different results than an analyst with no experience. An advanced planning aid needs to aggregate the data inputs, apply explicit knowledge converted from practitioners, and then create these products.

The analysis in Step 1 and 2 is largely focused on the weather, civil factors, sea state, and terrain, while the adversary is briefly introduced as a lens to view the battlespace through. In Step 3, the adversary is the focus and is where the analysts working this process should develop an in depth understanding of the adversary. Figure 21 displays the inputs and outputs of Step 3 and shows the first time in the process where the adversary is the primary focus.

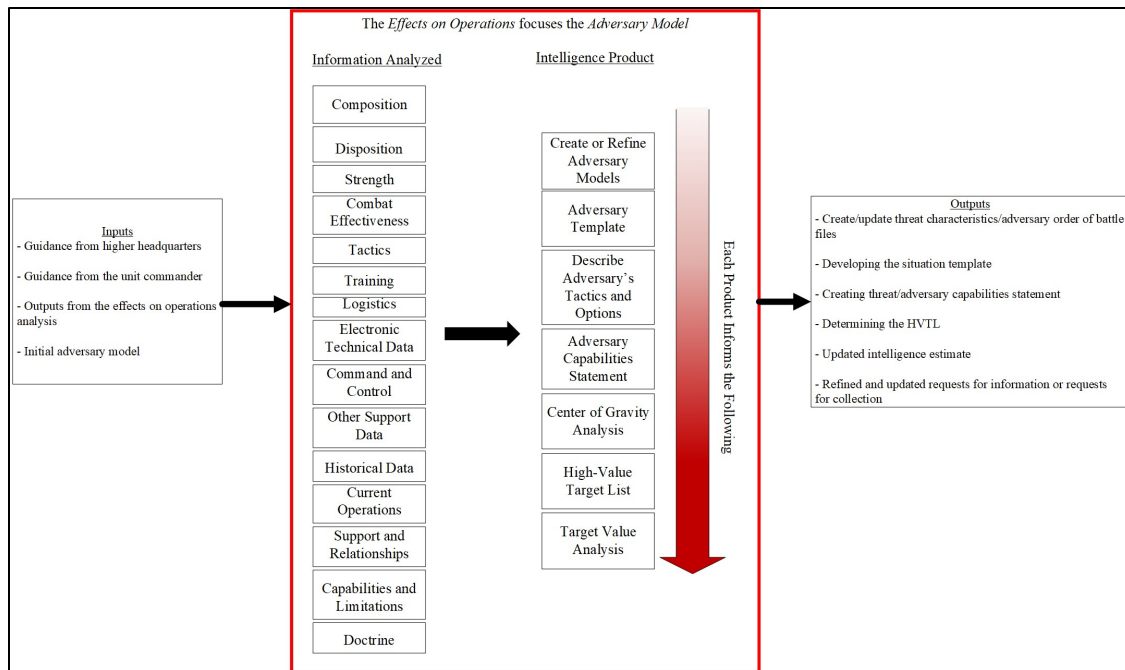


Figure 21. Step 3 Inputs and Outputs. Adapted from USMC (2014).

Step 3 is described as the intersection of the *Effects on Operations* and the *Adversary Model*, which is displayed at the top of Figure 21. The adversary characteristics listed under *Information Analyzed* in Figure 21 form the *Order of Battle Files*. These information inputs are requirements to the intelligence products on the right under *Intelligence Product*. Each characteristic, analyzed from the perspective of the previous step, informs the following product as shown by the red arrow in Figure 21. Once the intelligence section has a firm understanding of the assets available to an adversary and how they can use them in the battlespace, Step 4 can begin.

Before identifying the requirements for Step 4, it is important to note that the type of adversary needs to be identified before beginning this process (*conventional*, *irregular*, or a *hybrid*). The type of adversary and operation can focus the intelligence section on more relevant factors in the process when timeliness is the priority. Additionally, it may be difficult to quantify some of the adversary characteristics. Identifying max effective range, for example, of a naval missile is a much easier problem than capturing the combat effectiveness of a unit—max effective range is easy to represent in a ratio scale, where

combat effectiveness is more difficult. Two data inputs to combat effectiveness are status of training and efficiency of leadership, which are subjective and difficult to measure.

At the end of Step 3, the adversary and battlespace analysis are complete; meaning the physical space is understood and an adversary model is developed. There should not be any additional data points added in Step 4 directly. Therefore, Step 4 is an analysis of information and planning products from Steps 2 and 3. The inputs, analysis, and outputs of Step 4 are shown in Figure 22.

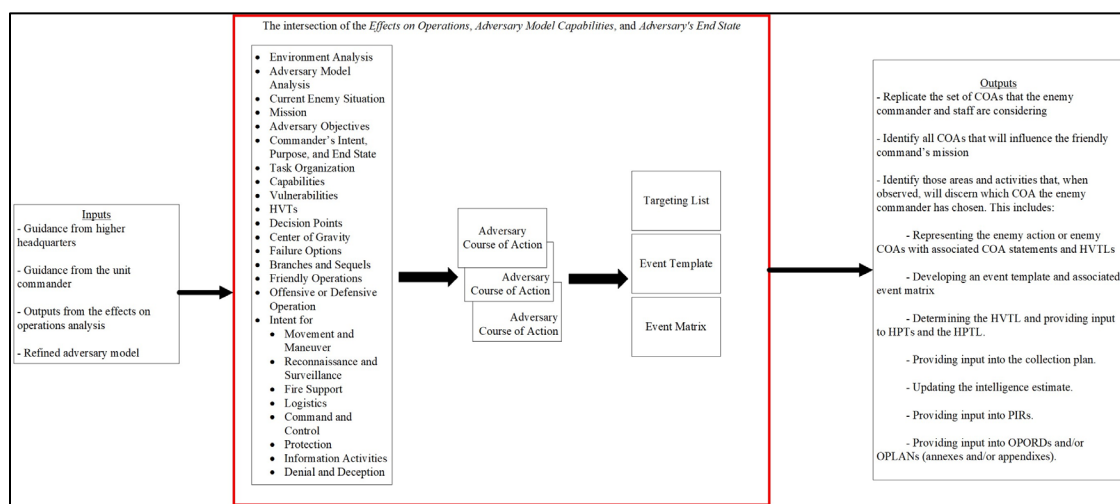


Figure 22. Step 4 Inputs and Outputs. Adapted from USMC (2014).

Step 4 has several very important outputs that focus the staff and provide a forecast for the commander to focus his efforts. The analysis conducted in this step is largely time dependent because the adversary COAs can be endlessly analyzed and refined. According to the IPB publication, this is a six-step process.

1. Identify likely objectives and end state.
2. Identify the full set of COAs available to the threat/adversary.
3. Evaluate and prioritize each threat/adversary COA.
4. Develop each COA in the amount of detail time allows.
5. Identify HVTs [High Value Target] for each COA.
6. Identify initial collection requirements for each COA. (USMC, 2014)

This step, as shown at the top of Figure 22, is the intersection of AO characteristics, adversary model capabilities, and the adversary's end state. Each of the COAs created through this process should be rated on their likelihood of occurrence and evaluated on the following criteria: feasible, acceptable, suitable, distinguishable (uniqueness), and complete (reference Chapter II for definitions). These evaluation criteria are the same for friendly COA generation—MCRP 2–10B.1 references MCWP 5-10 and notes that the adversary COAs “are developed in the same manner as friendly COAs.”

In practice, an intelligence section may see many COAs but only the most likely and most dangerous are presented. Some military officers, like Adamski and Pence (2019), argue we should take a probability-based approach instead of choosing a binary set of COAs. The IPB publication has a similar structure for developing COAs; the publication does not limit an intelligence section to only two COAs, but states that the most likely and most dangerous are minimum requirements—although, by convention intelligence planners limit the brief to a commander to two COAs. The difference between the probability-based adversary COA proposal and MCRP 2–10B.1 is that the doctrinal publication does not provide a methodology for handling probability. Adamski and Pence provide a general framework of rating the likelihood of individual events and the risk to force. A COA can then be created from the most likely events (Adamski & Pence, 2019).

The adversary COA has many inputs, or elements, such as their end state and objectives. The end state “is the desired conditions that, if achieved, meet the conditions of policy, orders, guidance, and directives issued by the commander (USMC, 2014).” The adversary's objectives help achieve the end state and can be terrain or enemy focused. These are goals that are “clearly defined, decisive, and attainable” in which operations are directed (USMC, 2014). The intelligence section needs to accurately identify the end state and objectives because they focus almost every other input in developing a COA. Furthermore, these characteristics of an adversary COA define the *what* and the *why* of the adversary's actions, which leaves most of the uncertainty in the *how*.

After the end state and objectives are identified, COAs can be created. Each adversary COA should have the elements listed in Figure 22 after the inputs, which make up a COA statement. Upon the completion of each COA, a refined targeting list, event

template, and event matrix can be created. The entire process is designed to produce these few intelligence products that support the unit's staff. Of these intelligence products, the event template and matrix are the tools that bound uncertainty by showing how, spatially, and temporally, resources can be allocated to confirm adversary forecasted movement or detect deviations in the forecast.

C. INTELLIGENCE SUPPORT TO CURRENT OPERATIONS

The previous section was about intelligence support to planning which happens before an operation begins. During the execution phase, the supporting intelligence section exists to support the operations section. This includes maintaining situational awareness of adversary units in the battlespace. It is anticipated that carefully designed advanced planning aids or a digital planning environment will be able to support the plan execution and replanning once operations begin. Therefore, it is imperative that these tools, integrated into operations, need an accurate view of unit locations in the battlespace which is achieved through battle tracking. According to Marine Corps Warfighting Publication 2-10 (2021), there are six functional intelligence areas that support operations which are listed in Figure 23.

Intelligence Functions	Decision Making	Operational Activities
Develop the commander's estimate	Plan a mission	Develop and analyze COAs
Develop the situation	Execute the mission	Monitor execution Modify plan as necessary
Provide indications and warning	Orient on contingencies	Increase readiness Develop contingency plans
Support force protection	Employ preventive measures	Support operations security CBRN defense Support deception plan
Support targeting	Plan fire support	Attack targets
Support combat assessment	Reorient forces Plan future operations	Consolidate, pursue, exploit Re-attack targets
Legend CBRN chemical, biological, radiological, and nuclear		

Figure 23. Relationship Between Intelligence Functions and Operations.

Source: USMC (2021).

The intelligence section supporting current operations needs to provide the support listed in Figure 23. The scope and scale of the support changes with the supported unit; however, the general framework is the same. The intent of battle tracking is to “add meaning to relevant information by formatting, plotting, translating, correlating, aggregating, organizing, categorizing, analyzing, and evaluating it to create the common operational picture (COP) (USA, ATP6-0).” Battle tracking is the most important support an intelligence section can provide; it forms the foundation for all other supporting efforts, such as collections, updating COAs, and targeting. Battle tracking methodologies range from rocks in terrain models to software on information systems—any digital planning environment needs to integrate with each warfighting function’s software that contributes to the COP.

Unfortunately, there is not a standard battle tracking process, so it is at unit discretion. As noted in ATP 6-05 (2017), “battle tracking methods should be documented in the command post standard operating procedure, trained, rehearsed, and understood.” This will generally consist of filtering reports from sensors, logging the reports, comparing the new information to existing information, making interpretations, and then integrating any changes into the operations. A notional example of this is displayed in Figure 24.

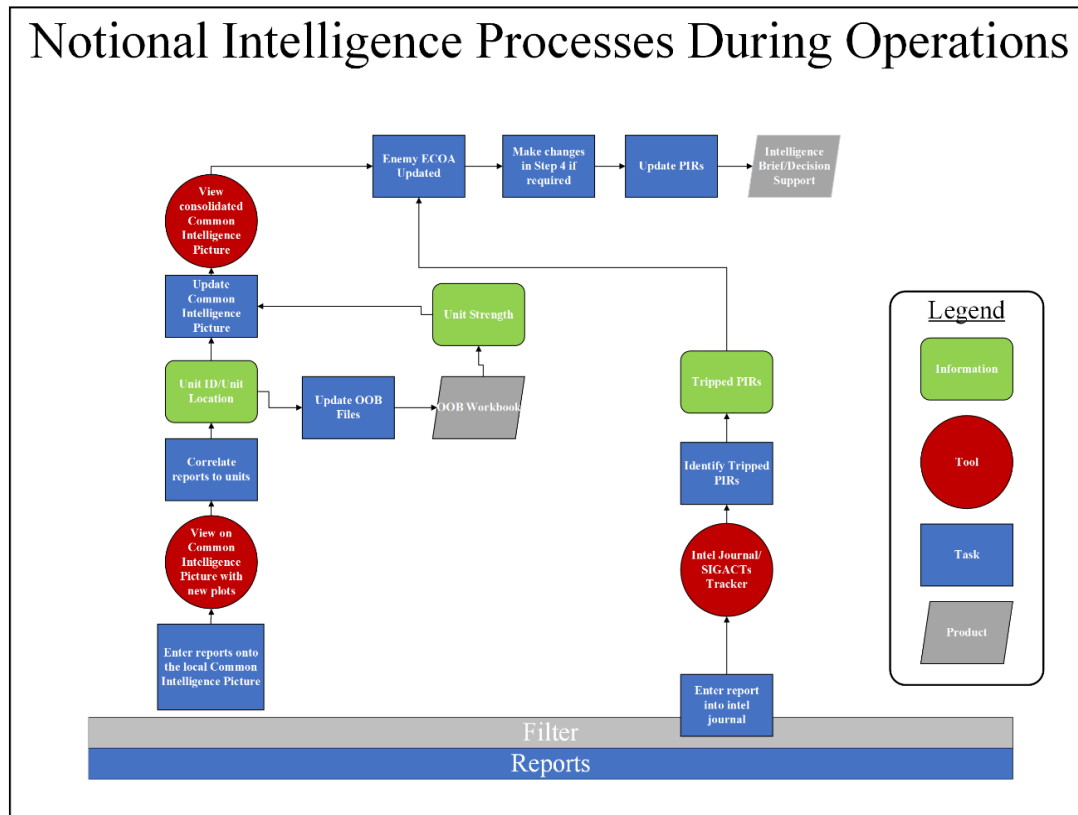


Figure 24. Notional Intelligence Processes During Operations.

Figure 24 displays a sequence of information, tools, tasks, and products that are required to battle track. The output of this is an updated COP and an intelligence brief that goes to the commander of the battlespace. Also, this process is how the IPB is updated during mission execution. Figure 18 in Chapter III represents the flow between the EVE structure and the IPB which is important to support planning. The EVE structure can provide continuous refinement to existing intelligence products that never get revisited because of high operational tempo.

D. INTELLIGENCE SUPPORT TO EVENT-VERB-EVENT (EVE) CHAINS

The intent of advanced planning aids is best described by a U.S. Naval Institute article about digital planning environments (Clary, Contreras, & Hamrick, 2023). The authors express the need to use rapid modeling and simulation aided by artificial intelligence to support this environment. This requires a consolidated data structure that is

accessible by planners and planning tools. This environment would better support planning efforts by analyzing far more parameters than human planners can and may prevent plans from stagnating. For instance, the intelligence products in Step 2 and 3 of the IPB are difficult to maintain during operations, resulting in outdated intelligence. However, this can be prevented by employing the digital planning environment presented by Contreras and Hamrick. This idea is also embedded in the EVE structure, which will be able to model complex military environments by evaluating traditional planning inputs via machine learning and artificial intelligence.

As noted in Chapter III, an Event Verb Event (EVE) chain is a series of actions and states that make up an adversary COA. Traditionally, military intelligence planners use the event template and event matrix for this which is a decision tree transposed over a map. Figure 25 displays a theoretical process version of an event template with EVE characteristics.

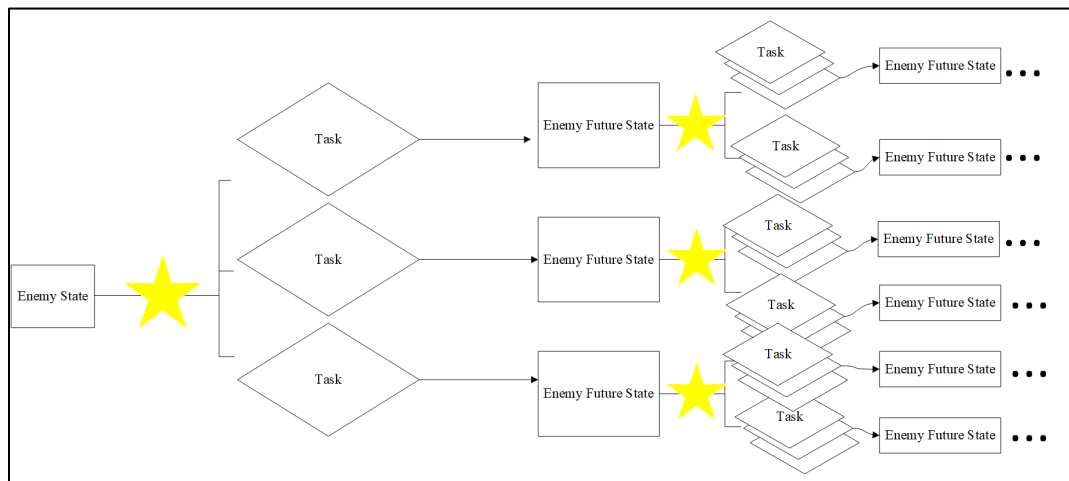


Figure 25. Theoretical EVE Chain Template describing COA Variations

The yellow stars in Figure 25 represent enemy decision points. The adversary has three possible tasks to employ in the first decision and then each of those tasks have a future physical state in the battlespace. This repeats until there are no more decisions, and the desired end state is achieved. Once the decisions are identified and assigned observable

characteristics, named areas of interest are created to begin the collections plan. Figure 26 is a simple example of an event template.

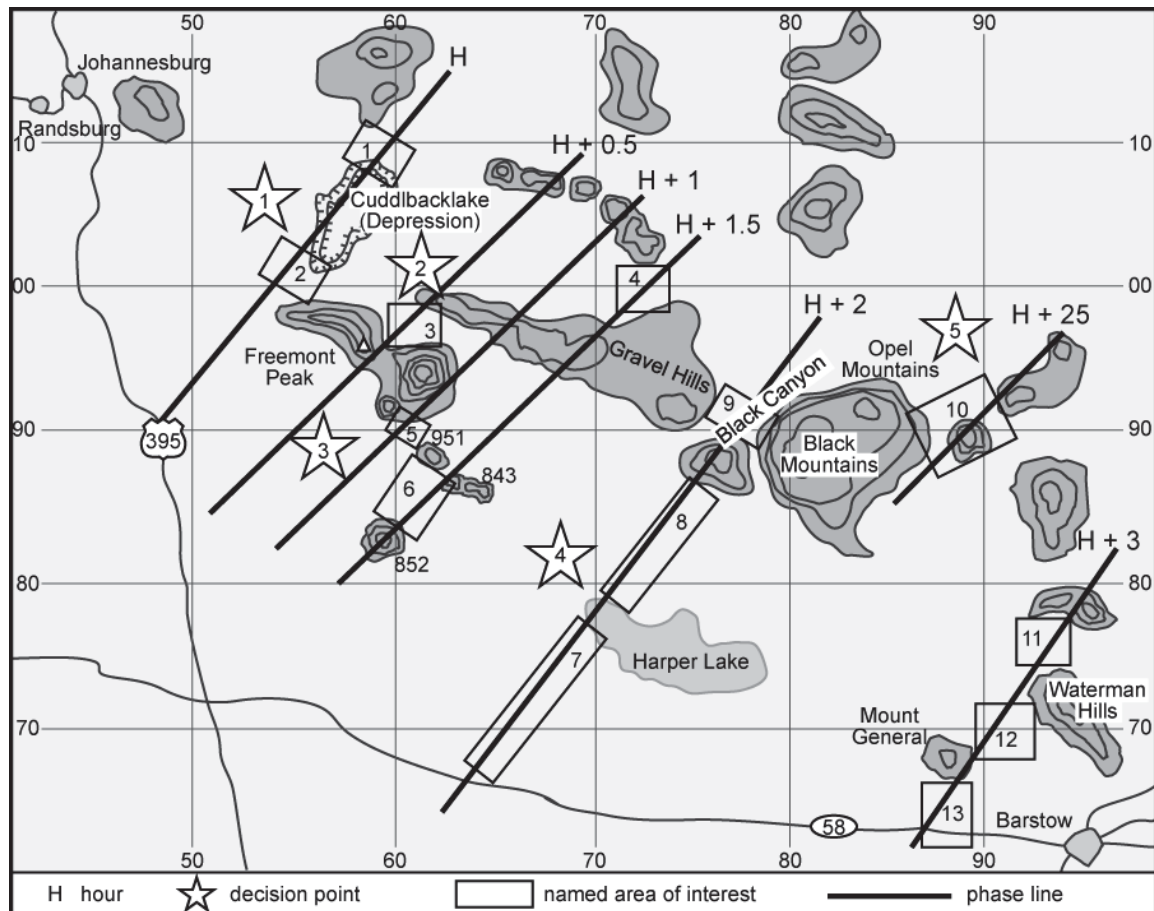


Figure 26. Doctrinal Event Template. Source: USMC (2014).

A required input for the event template is a set of COAs and decision points that make them distinct. The COAs are comprised of a series of task and purpose statements that transition an adversary from their current state to their end state. Intelligence planners conduct a functional analysis in adversary COA generation to understand how an adversary can use its capabilities to transition states and achieve their objective (USMC, 2014). The functional analysis considers the current state of an adversary, their objective, and what the adversary model can achieve, when bounded by environmental factors. This type of analysis is composed of the functions in Table 6.

Table 6. Types of Adversary Functions. Source: USMC (2014).

Function	Definition
Action	The function that accomplished the adversary's objective.
Enabling	The function that facilitates the accomplishment of the action in achieving the objective.
Fixing	The function that prevents opposing capabilities from interfering with the mission.
Security	The function that performs a set of capabilities that acts to protect other capabilities from observation, destruction, or becoming fixed.
Deception	The function that leads the enemy to act in ways prejudicial to enemy interests or favoring the success of a threat/adversary action force or element.
Support	The function that provides sustainment or command and control capabilities.
Reserve	The function that provides a commander influencing ability over unforeseen events.

Based on the developed adversary model, the functions are assigned to subordinate units or supporting elements. This analysis identifies all the functionality a unit can provide to support an adversary in achieving their end state and associated objectives. Furthermore, this analysis limits the temporal and spatial permutations due to the inherent resource limitations of an adversary. The list of available actions is identified in Step 3 and then logically compiled in Step 4. The EVE structure can support this analysis through its verb structures and ontology, which is displayed in Figure 27.

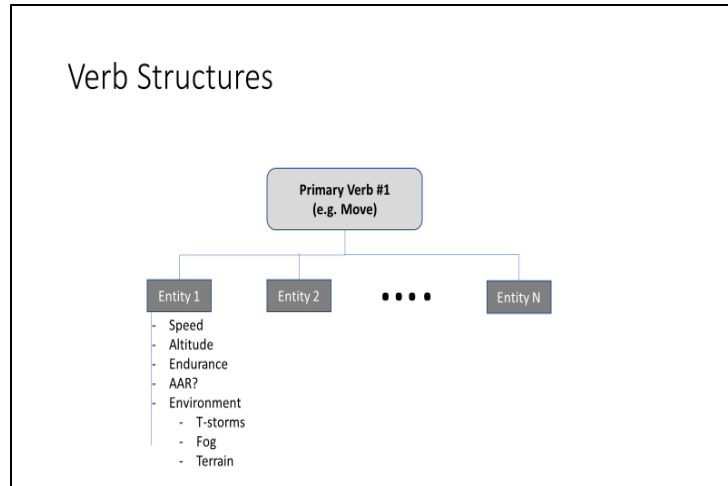


Figure 27. EVE Verb Structure. Source: Nagy (2022).

Figure 27 shows a verb, the entities that can employ the verb, and what characteristics are required to use the verb. This structure will also require a verb table with the columns: rules to determine verb, input variables to verb, output variables from verb, and the statistical form of variables predecessor verbs (Nagy, 2020). The information requirements in these columns can be satisfied by the doctrine and tactics, support and relationships, and disposition reviews in Step 3. These inputs will identify which units were intended to deliver a capability, how a supporting/supported relationship can provide a capability, and how the factors in the battlespace impact the unit’s ability to deliver—it is important to note that this table must be created for every verb. The intelligence inputs to the EVE structure are displayed in Figure 28.

EVE Structure with Intelligence Support				
Predecessor Event = <i>Situation Template</i> or <i>Previous Successor Event that Belongs to a Mission</i>	Verb = Possible Verbs Available to an Adversary = <i>The Intersection of the Available Actions from Effects on Operations and the Available Tasks by the Adversary Model</i> Preferential Verb Sequence = <i>The Intersection of the Verb List, Possible Verbs Available to an Adversary, and TTPs that support the Requirements of Adversary Objectives</i>	Mission = Remaining Objectives that Belong to an End State	Enabler = Capabilities Required by Verb Identified in Step 3	Successor Event = Adjudication

Figure 28. Intelligence Support to EVEs

The sum of inputs into the EVEs shown in Figure 28 from the current state to the end state represent an EVE chain which equates to a COA traditionally generated in Step 4. The predecessor event is the situation template, or the previous successor event, that belongs to the mission. In tactical military planning, units are assigned missions that have required task and purpose statements. Tactical tasks are generally planned and executed in a sequence when proper pre-conditions are achieved. If it is the first task, then there may be no pre-condition; all other tasks are the outcome of the prior EVEs adjudication.

The verb selection can be broken down into two categories from the IPB. The possible verbs available to an adversary is the intersection of available actions from effects on operations and available tasks by the adversary model. This filters the tasks an adversary can perform through the impacts the environment has on their equipment. The second verb category is preferential verb sequence, which are conditions-based tasks. The preferential verb sequence is the intersection of the verb list; possible verbs available to an adversary; and their techniques, tactics, and procedures (TTPs) where they support the requirements of the adversary objective.

The mission is the remaining objectives required to achieve the end state, which can also be described as a series of tasks. A mission must be appropriate for a unit; appropriateness is measured by the characteristics analyzed in Step 3 of the IPB process. A mission will require an enabler, which are any tasks, or conditions, that are required to use the verb to transition states and will determine the required task organization for the EVE. The enablers will identify supporting relationship requirements that are identified in Step 4 of the IPB process but the information to support this analysis is in Step 3. The successor event is the adjudication of the friendly EVE and the adversary EVE where they intersect.

The EVE structure can also be represented as a product series rather than a sum. This form represents the conditional probability of an EVE occurring. The IPB process is designed to reduce uncertainty and mentions ranking adversary COAs on their probability of occurring, but it does not provide a mechanism for determining probability. In practice, military judgement is used to determine probabilities and then expressed in terms described in *Intelligence Community Directive 203* (ODNI, 2015); the uncertainty vocabulary is

displayed in Table 3 in Chapter II. The challenge is converting military judgement, which inherently creates probabilities, into repeatable analysis by an advanced planning aid.

The actions in each COA developed in Step 4 have a probability and are dependent upon the many environmental and friendly effects. The EVE structure can process this type of data to support planning. Introducing technology that can exhaustively analyze future states, and assign probabilities, could expose critical states that are like all COAs—which may take the form of a scale free network, displayed in Figure 29 (Barabasi, 2009). A scale free network is composed of nodes and connections where preferential attachment develops more influential nodes in the network. One of the measures for COA validity is uniqueness, but several COAs could require a similar state as a pre-condition for other future states. This means that an advanced planning aid could find relations in missions—states and verbs that are required for numerous COAs—that humans may not see or would take too long to find.

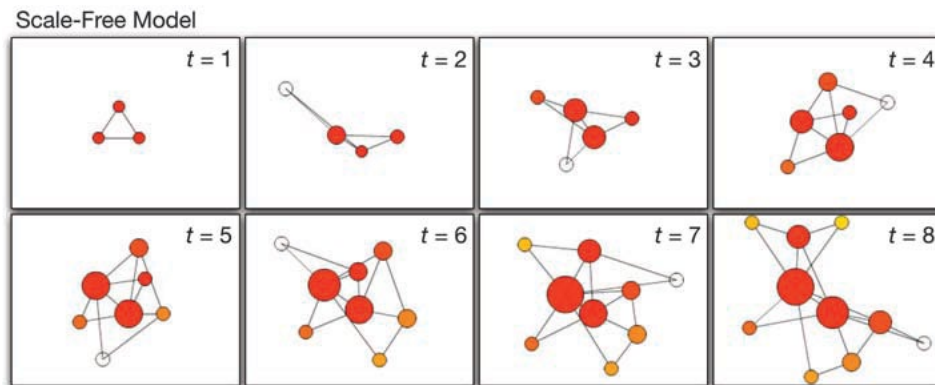
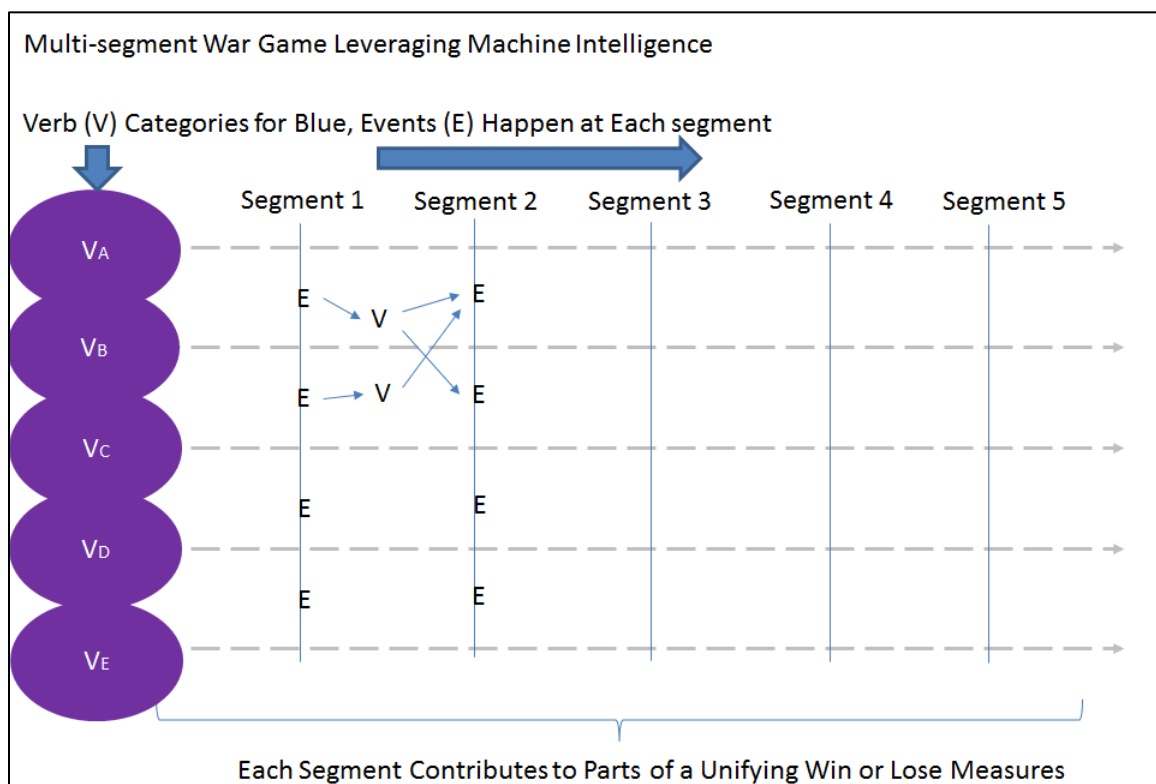


Figure 29. Scale Free Networks. Source: Barabasi (2009).

The scale-free model shown in Figure 29 shows how some nodes in a network are more influential because they have more connections. The larger red circles represent the influential nodes; they have more connections than the smaller red or orange circles. An example of this is an airline network; larger airports have substantially more connections than smaller, regional airports. This means that the larger airports are more influential in the network and are more likely to be included in a traveler's route. Similarly, COA

generation by a digital planning environment like TAWC can find the most influential verbs and states by using a multi-segment wargame, as shown in Figure 30. A multi-segment war game is a war game with two opposing asymmetrical players that is divided into segments with events and actions, alternating between players (Zhao & Nagy, 2020). Several iterations of this could reveal more influential locations and actions required to support numerous possible COAs, much like a large airport.



This approach can also assist in developing a center of gravity (COG) analysis. The center, or centers, of gravity are sources of strength that are critical to the enemy (USMC, 1997). This analysis is conducted by both the friendly and adversary COAs. For the intelligence section, this is done in IPB Step 3 after the adversary model is created and then applied and tailored in Step 4 for each COA. The USMC accepted approach to COG development is known as the *Dr. Strange Method*. The basic structure is composed of a center of gravity (a noun), critical capability (a verb), critical requirement (a noun and verb), and the critical vulnerability (a noun and a verb) (Strange, 1996).

The COG analysis in practice is tough to agree upon since a person's epistemology shapes their view on the value of warfighting assets. However, an aid like TAWC may provide a more objective approach in identifying the elements of a COG analysis. If the EVE structure identifies common states and verbs that are required for COAs with the highest probabilities, then we would better identify critical requirements and vulnerabilities that belong to COGs and optimize targeting efforts.

The inputs for EVEs are the same as the inputs for COA development in the Marine Corps Planning Process (MCP): the battlespace framework, array of forces, purpose and tasks, task organization, sequencing, phasing, integration, control measures, and the problem. Each information requirement for the EVE structure can be supported from the IPB because they are the same requirements for Step 4. For the EVE structure to be integrated into military planning, it must be able to analyze the information presented in this thesis. Inputs like guidance and end state will be difficult to capture, but they can be drawn or written as physical battlespace effects. According to Marine Corps Doctrinal Publication 6 (2018), images are preferred for representing data and commanders rely on three different pictures, the closeup situation, overall view of the situation, and the enemy's perspective.

Since we plan and understand the battlespace pictorially, we can interact with an advanced planning aid with pictures as well. The adversary's end state can be drawn as an overlay, then converted into a usable data structure by the aid. Current battle management aids have an overlay capability so it would be an easy transition for intelligence planners. Moreover, military decision briefs contain lots of pictures to help a commander develop a

better understanding of the environment, so this is a must for any advanced planning aid (note: TAWC will use natural language processing for this, but object detection could also interpret these inputs).

E. REPRESENTING UNCERTAINTY

The IPB process is the military's current way of reducing uncertainty in adversary actions, but it has many limitations, most of which are human shortfalls. We are very slow at processing the variety and volume of data produced by all the intelligence disciplines. As an example, Figure 31 represents the task organization of a Marine Expeditionary Force Intelligence Operations Center; notice the number of sections and diverse unit representation displayed. Each section analyzes data and produces intelligence products which are inputs for further intelligence production.

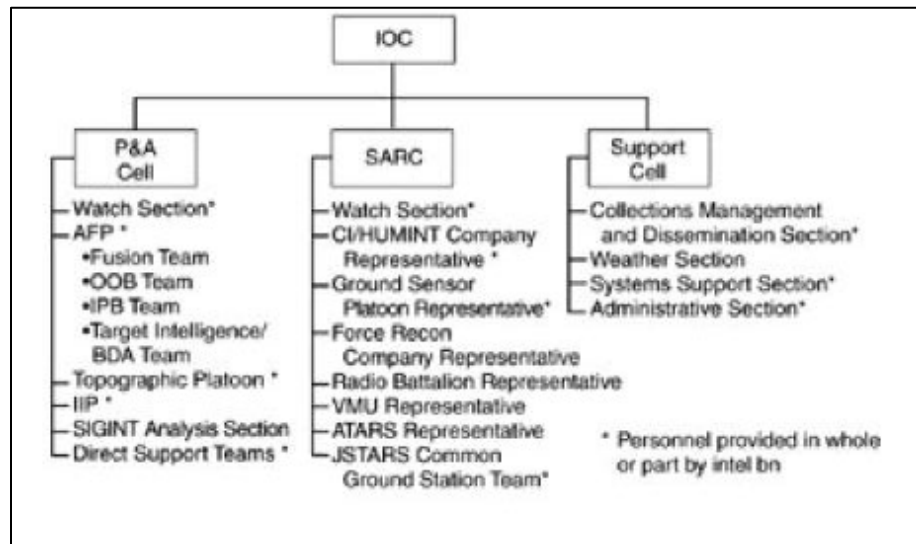


Figure 31. Marine Expeditionary Force Intelligence Operations Center.
Source: USMC (2016).

In Chapter II, the shortfalls of the Military Assistance Command, Vietnam were presented along with the findings of a team's strengths in chess tournaments. The task organization displayed in Figure 31 performs well for large, rear area operations centers, but there are some shortfalls. The current information systems and software employed in a

structure like presented in Figure 31 do not cohesively interact and help generate COAs. Each section uses software to derive required intelligence, but the analysts aggregate the information to form or update COAs. Since this type of technology does not exist and data derived from sensors is growing, intelligence analysts have a limited capacity to employ analytical techniques that would potentially discover unknown unknowns.

The EVE structure can solve this problem. By processing large amounts of information quickly, it aims to reduce the impacts of known unknowns and unknown unknowns. The known unknowns are either turned into collections requirements or are replaced by assumptions (USMC, 2014). If an assumption is used, it is imperative to document why and how they were made. The unknown unknowns are more difficult to handle because they need to be discovered. It is important to note that the IPB process exists to answer both types of unknowns, but the challenge is answering the remaining questions or identifying data that was not revealed through this process.

One method of unknown unknown discovery is through structured analytic techniques (SATs). SATs help intelligence analysts “overcome their cognitive limitations by using systematic problem-solving processes that facilitates collaboration (RITC, 2022).” Some of the techniques taught in Marine Corps training is brainstorming, red hat, outside in, alternative futures, indicators, analysis of competing hypothesis, and key assumptions check (RITC, 2022). The techniques are employed if proper time is available but are limited by the experiences and diversity of the group—which advanced planning aids can help overcome. The second method of discovering unknown unknowns is by incidental collection. This means that a collection request was submitted, and the feedback returned unintended but relevant information. An additional method of discovery is by reviewing another entity’s collection for important information to your operation.

Possible futures can also be explored by changing the parameters of data inputs in the IPB. As noted in Chapter III, there are generally four types of uncertainty: weather, civil, adversary, and terrain. An example of changing the model parameters would be adding or subtracting equipment to an adversary unit. It is likely that the documented number of assets a unit has is incorrect. There is most likely not a large discrepancy, but even a small deviation in OOB numbers or capabilities could change a forecast. To

represent this uncertainty, the OOB numbers can be simulated with Monte Carlo techniques to add randomness into the model.

A substantial limitation of this methodology, for example, is identifying the mean and standard deviation of each OOB category. The analyst can assume the mean is their current OOB estimate, but the standard deviation is a more difficult problem. This would need to be a setting for the user to set an uncertainty level in the planning aid. An intelligence analyst would likely have more certainty in the location of principal, high level weapon systems and less certainty about supporting OOB. Furthermore, the analyst can cross reference the OOB workbook with doctrinal templates, task organization, and the battle damage assessment tracker to develop a better understanding of their uncertainty. An advanced planning aid could also perform this function if the data is structured appropriately. This same approach can be applied to the other areas of uncertainty.

Integrating the IPB process with the EVE structure has several intersection operators. All possible adversary actions are bounded by terrain, weather, and civil considerations. Introducing randomness in each of these categories would expand, or contract, the possible actions available to the adversary. This is not just limited to OOB counts or terrain trafficability; details like OOB parametric data or material strength need to be simulated as well. This would account for things like a landing craft being able to land on more beaches than anticipated and friendly munitions being less effective than planned.

F. SUMMARY OF THE ANALYSIS

The process for developing an adversary COA is very detailed and provides an important logical framework for analysts. However, there are some pitfalls in the process; for example, it takes a substantial amount of time to produce a COA and the intelligence products can stagnate because of competing requirements. These pitfalls limit the quality of analysis provided by an intelligence section or grow it into an unmanageable mass of people that form an incredible targeting opportunity. To achieve an optimal division of labor, tasks within the IPB process need to be marked best fit for humans or automation. Humans have a very important role in the process as noted earlier in the chapter by guiding

the intelligence analysis and confirming the outputs provided by automation. If a software tool like TAWC can aggregate data and form, at worst, rudimentary connections between units and actions, humans can focus on analyzing the outputs rather creating the inputs—**except for where guidance is required**. This guarantees that this process that may get placed on the back burner during operations gets continuously updated.

If this can be achieved, models like metarecognition and SATs will be even more effective in supporting the team like the *Playchess* tournament. The humans in the process can spend more time analyzing the low probability, high impact events that fall outside of the normal distribution presented in Chapter II. The possibility of analyzing far more possible futures because of a program like TAWC also provides similar functionality as the metarecognition concept, possibly exposing blind spots caused by bias. Advanced planning aids can correct these shortfalls if the software properly represents, or compliments, military experience in mission planning. The overall output of this is higher quality decisions to support commanders with less resources supporting modern operating concepts.

V. CONCLUSION, RECOMMENDATIONS, AND AREAS FOR FURTHER RESEARCH

This thesis explored the relationship of data requirements and intelligence outputs required for planning, and how they can be integrated into an advanced planning aid. While the EVE structure is still theoretical, the relationships between existing doctrinal processes and new technology need to be integrated throughout the entire process. Technology integration without regard for doctrinal processes can lead to expensive gear and software that is only touched during inventory accountability.

This research used an emphasis on ground combat planning, but the findings would apply equally to other warfare domains. For instance, the Marine Corps uses the Modified Combined Obstacle Overlay to envision the topographic environment. The Navy uses bathymetry, oceanographical observations and sound propagation models to deduce the undersea environment in similar ways.

A. SUMMARY OF THE ANALYSIS

Chapter IV listed the inputs and outputs for the Intelligence Preparation of the Battlespace (IPB) and its relationship with The Automated White Cell (TAWC). The process and relationship with TAWC, at a high level, is simply a series of inputs, analysis, and outputs that support course of action (COA) generation. The need this satisfies was described in Chapter I, by calling to attention the manpower requirements of distributed operations and the increasing need to reduce uncertainty. Moreover, substantial refinement is required to intelligence process data models before an advanced planning aid can be integrated into the overall planning processes. Copying data from intelligence community databases and then storing it into slide shows or spread sheets will not support this type of technology integration.

This approach to intelligence support is flawed in many ways. The first problem is data storage; the military would benefit from employing advanced database structures to integrate capabilities like TAWC. Retired Army Colonel Harry D. Tunnell (2020) argues that we need relational database management systems to standardize data and provide

better access. The closest data storage methodology to this employed at the tactical level is share point which is not comparable. The second problem with the current approach is that it is outdated. Very few steps in this process are automated which creates a natural tension between quality and speed. The traditional Marine Corps solution to eliminate this tension is to have intelligence products ready so the supporting intelligence section has a head start. While this approach can be effective, it is manpower intensive and requires some guess work to predict where the next fight will occur.

The integration of an advanced planning aid will provide a mechanism to analyze high volumes of intelligence data which is not currently available to military personnel using contemporary information systems and software. Moreover, a digital planning environment could explore far more possible COAs by exhausting most possible permutations and by altering the model parameters to assess its implications on COAs. Ultimately, the combination of the IPB process, proper data storage techniques, advanced planning aids, and uncertainty representation in COA generation will help identify potential surprise scenarios for planners, establishing conditions for improved operational performance. In essence, instead of advanced planning aids applying one subjective indicator of uncertainty to the process, leveraging the process laid out here enables planners and the planning aid to break down uncertainty into smaller components, thus reducing the risk inherent in subjectivity and bias.

B. RECOMMENDATIONS

The following recommendations are listed in priority order for all-source intelligence support to adversary COA generation and general planning efforts.

1. Automation. Generally, analysts know where to search for information because intelligence agencies are responsible for certain types of intelligence or aligned functionally. Analysts also know that the information needs to be copied over to a spreadsheet, slide deck, or software, like Agile Client—Agile Client is a military program of record that supports command and control. To support manpower reduction, the IPB process needs to be automated. This is not a simple problem; there are

classification, security, and interoperability issues that plague the process, but it is doable. But before the automation can be successful, the data types and file formats need to be standardized. This is a much larger problem that nests within the Joint All-Domain Command and Control strategy (DOD, 2022), but the DOD would benefit if it was considered more in the planning phase of the intelligence cycle. Relational databases were previously mentioned, but there are other options, such as graph databases, if this model does not best fit intelligence process and threat modeling. Regardless of the specific technology or software, intelligence as a warfighting function would substantially benefit from integrating modern technology and a good data model that is automatically updated.

2. Analysis. Military intelligence analysts use many analytical techniques to support the IPB process. In the Marine Corps, the analytical approaches are described in Marine Corps Tactics Publication 2–10B (2016). The analytical and reasoning techniques are designed to test the story that the data presents and the user’s knowledge to avoid analytical pitfalls. However, the understanding of military operations that is developed through studying an adversary forms the basis of the analytical function. The percentage of active-duty personnel with combat experience (a synonym for this is hands on experience) is dwindling rapidly; the collective knowledge of an intelligence section is the most important input in forecasting an adversary COA. These experiences are incredibly important in planning and need to be incorporated into planning aids; people without experience dealing with novel situations can create a bottleneck and constrain decision making processes (Endsley, 1997). The knowledge of the experienced personnel needs to be converted into an ontology that represents relations in excruciating detail, which could reduce the bottleneck problem. This thesis described the high-level relations, but software developers need to know how intelligence professionals logically connect data to form the intelligence products

discussed in Chapter IV. Additionally, the *Measurement and Evaluation of Military Intelligence Performance* (Thompson, Thompson, Fichtl & Adelman, 1989) technical report mentioned in the literature review needs to be recreated with a larger, more diverse sample size. The author's framework for capturing relative importance for each intelligence input is important in advanced planning aid development. The bottom line is that tacit knowledge must be embedded into an advanced planning aid to support automated COA generation. It is important to note that Endsley (1995) mentions a tradeoff between automation and responsiveness to new stimuli, meaning that users are receiving the outputs of the automation rather than reviewing new information. This is an important issue for advanced planning aids and can likely be solved by integrating modeling expertise into intelligence sections and thoroughly examining the appropriate human touch points in the IPB process.

3. The Output. The intelligence products in each step of the IPB process tell a story about the battlespace and military planners are familiar with these outputs. These outputs support every warfighting function and most staff functions. Pictorially representing the data, analysis, and the effects is important to the usability of an advanced planning aid. For example, verbs in the Event-Verb-Event construct translate to tactical tasks which are represented by symbols in Military Standard 2525 (MIL-STD-2525). Additionally, there are standards for intelligence products, like imagery analysis, that are governed by the functionally responsible agency. The DOD would benefit from an advanced planning aid that used visualization techniques that complied with current standards or mirrored common standard operating procedures.

The benefit of automating data inputs, developing an analytical capability, and producing the intelligence products is allowing the intelligence analyst to focus on developing future states more thoroughly, rather than spending most of their time aggregating data. The likelihood that any one of the several COAs an intelligence section

creates is correct is low but allowing a machine to perform most of the functionality frees up analysts to examine the low probability, high impact events that may devastate a plan, leading to a higher level of preparedness.

What this research is not suggesting is that automated functions replace human intelligence or that military analysts should not be intimately familiar with the first three steps of IPB; rather, the findings in this research exhibit a place to develop a competitive advantage by shaving time off long, tedious processes that are foundational in reducing uncertainty. It is the fundamental responsibility of personnel within the intelligence warfighting function to close decision loops with limited conjecture. IPB is a process that uses technology in a supporting role on the periphery and does not capitalize on the benefits presented by modern technology. The integration of TAWC can concentrate technology at the core of the process and place humans on the periphery, examining the principal intelligence outputs, byproducts, and managing how the technology interacts with data.

Said in another way, the current model involves a human interacting with information technology to pull information and then enters it into another form of information technology for analysis or visualization. The output is an updated mental model and is analyzed by the knowledge of the user. The current model is very effective at forcing intelligence analysts to examine the details of a battlespace.

An intelligence model that incorporates TAWC would remove the human from the center of the process, and they would have less touch points with the data. For example, the analysts would not go to many different websites to pull information and then enter that information into software to perform the analysis for a supporting intelligence discipline. Instead, the analyst would examine the input, perform analysis, and then examine the output to compare the expected outcome with the actual output of the planning aid. Additionally, the analyst would then examine the details of the analysis provided by the aid that he did not expect in further detail. The benefit of employing TAWC in the process is signified by the *Playchess* tournament example, where the expertise levels of technology and chess were different.

C. FUTURE RESEARCH

Future research along these lines includes developing an ontology for elements in the intelligence production processes to support advanced planning aids. Most of the required information is already stored across the intelligence community, it just needs to be aggregated and normalized. This will support planning aid software development by capturing the knowledge used in intelligence processes. Additionally, the tacit knowledge stored by analysts that understands adversarial characteristics as they relate to adversary COA actions needs to be documented. For example, what logical connections does an analyst make when they see a report about artillery positions in an adversary's defense? Does that analyst immediately recall the doctrinal template and then assess where the rest of the adversary is based on that information? TAWC can provide this level of support, but the software developers need a thorough understanding of how an assessment is made. This is also important for planning in specific scenarios, like humanitarian assistance missions.

All the data sources and required software need to be documented. The information in this thesis is generic, but more detail is needed in each step to be useful to a software developer. This includes not only all-source intelligence sources but also for every intelligence discipline and the responsible functional agencies. This will help solve the automation problem in this process.

Probability was mentioned in this thesis and in doctrinal publications. Additional future research needs to focus on how information gaps presented in Chapter IV can be converted into probabilities beyond the lexicon provided in Intelligence Community Directive 203. The process to get to an adversary COA is well documented but it is still unclear how experienced military planners intuitively assign probabilities. There are proposed methodologies, which were described in the literature review, but there is no open-source experimental feedback. Capturing this analytical process is important for the future of decision aids.

Chapter II highlighted two such issues:

1. While in one case computer aided support assisted planners, in another case the computer assist confused the operators and led to delayed

planning times and poorer decisions, exactly the opposite of the desired outcome.

2. In another case, a weighted average approach was used on information inputs from various users; however, in the example only four people were involved. A better “wisdom of crowds” approach needs to be researched, and on how such a process could be implemented into advanced planning aids (Surowiecki, 2004).

D. CONCLUSION

Martin Van Creveld (1985) identified many problems and fixes that technology provides in military command. The trend of needing more staff and computers to process the increasing quantities of complex data for decision making, and how new techniques like cybernetics and game theory—we can add machine learning and artificial intelligence to this list—were created to cope with the flood of data. To prevent, as Van Creveld said, “the danger of command becoming an end unto itself,” a digital planning environment must be integrated as a supporting planning capability rather than a replacement to traditional planning to help digest sensor information. It must also provide fast and clear situational understanding which can serve as a force multiplier and compensate for current weaknesses.

The desire for high volumes of information to inform decision making is not going away. We need advanced planning aids to support planning, in both long, methodical planning efforts as well as short, dynamic environments. This will not, and should not, replace environments that require intuitive, non-computational decision making; rather, it supports decision making cycles through creating a better understanding of the environment which can decrease decision timelines. Wilder ideas have been proposed to gain an advantage in processing data from intelligence sources, such as micro dosing Marine Corps intelligence analysts with drugs (Albayrak, 2019). While unorthodox, the authors point is valid; we need a radical change to process information faster than our adversaries, which can be provided by advanced planning aids.

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