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TECHNICAL REPORT

A Strategies-to-Tasks Framework for Planning and Executing Intelligence, Surveillance, and Reconnaissance (ISR) Operations

Carl Rhodes, Jeff Hagen, Mark Westergren

Prepared for the United States Air Force

Approved for public release; distribution unlimited

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Preface

The Air Force has faced challenges in recent conflicts dealing with emerging, fleeting targets that expose themselves to detection and attack for short periods. As these targets may be vulnerable for only a few minutes, response must be quick. A key part of an effective response to these challenging targets is an intelligence, surveillance, and reconnaissance (ISR) system that has appropriate sensors at the correct location when targets are exposed. To enable this, the ISR planning process must appropriately trade off among many competing priorities and tasks, while at the same time allowing flexible, real-time changes to the plan to occur with a minimum of delay and friction. This problem is further complicated by the low-density, high-demand nature of the ISR assets to be employed.

This report proposes ideas for improving ISR collection planning and execution through implementation of a strategies-to-task framework for collection planning. In addition, we explore here the benefits of a utility function–based collection prioritization scheme. Such a scheme could also enable better alignment in the Air Operations Center (AOC) between the ISR Division and other divisions. This work is part of an ongoing, larger study on ISR command and control, "Tasking and Employing USAF Intelligence, Surveillance, and Reconnaissance Assets to Support Effects-Based Operations," sponsored by PACAF/A2 and ACC/A2 and conducted within the Aerospace Force Development Program of RAND Project AIR FORCE. The intended audience of this report includes A2/N2/G2 staff at the joint and component command levels as well as analysts investigating future ISR command and control concepts.

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Summary

To assist in moving intelligence, surveillance, and reconnaissance (ISR) planning and execution forward from a fixed target and deliberate planning focus to one centered on emerging targets, we propose enhancing the collection management process with a strategies-to-tasks and utility framework. By linking collection targets to operational tasks, objectives, and the top-level commander's guidance with relative utilities, planning for the daily intelligence collections and real-time retasking for ad hoc ISR targets could be enhanced (see pages 9–17). When current tools are modified to provide this information, planners will be able to link collection targets to top-level objectives for better decisionmaking and optimization of low-density, high-demand collection assets. Similarly, on the Air Operations Center (AOC) floor, intelligence officers will be better able to deal with time-sensitive, emerging targets by rapidly comparing the value of collecting an ad hoc collection with the value of collecting opportunities already planned. In order to handle the ISR demands posed by the rapidly changing battlefield of the future, this new, more-capable framework may be needed for making the best use of intelligence capabilities against emerging collection opportunities. Future research will focus on quantifying the advantages of this approach in comparison with the current process.

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Col Mark Kipphut, Pacific Air Forces, is the original sponsor of this work. He provided numerous insights that helped initiate this line of research and helped us to refine our ideas on the topic of ISR planning and execution. Both his enthusiasm and knowledge contributed immensely to this work.

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Brig Gen Thomas Wright and Mr. Gary Harvey, Air Combat Command, hosted a data-gathering visit by our research team and also helped arrange visits for this research. Thanks to their help, we were able to participate in a session writing the concept of operations for assessing ISR operations.

Brig Gen (S) James Poss, Air Combat Command, and Col Martin Neubauer, Pacific Air Forces, provided useful comments on the draft version of this work to help improve it dramatically.

At RAND, we would like to thank reviewers Gary McLeod and David Thaler for their insightful comments and Holly Johnson for all her hard work in editing and formatting this document.

Acronyms

AOC	Air Operations Center
AOD	Air Operations Directive
ATO	air tasking order
BDA	bomb damage assessment
CCIR	commander's critical information requirements
CONEX	concept of execution
EEI	essential element of information
EO	electro-optical
EO/IR	electro-optical and infrared
GMTI	ground moving target indicator
IPB	intelligence preparation of the battlespace
ISR	intelligence, surveillance, and reconnaissance
JCMB	joint collection management board
JFC	joint force commander
JIPCL	Joint Integrated Prioritized Collection List
JIPTL	Joint Integrated Prioritized Target List
JTF	joint task force
PIR	priority intelligence requirement
PRISM	Planning Tool for Resource Integration, Synchronization, and Management
SAM	surface-to-air missile
RSTA	reconnaissance, surveillance, and target acquisition
WMD	weapons of mass destruction

CHAPTER ONE

Introduction

Recent conflicts and the ongoing long war against terrorist groups have placed a high value on having timely, accurate information about the adversary. As a result, intelligence, surveillance, and reconnaissance (ISR) assets have been in high demand. There are currently insufficient numbers of collectors to satisfy all requests for information, making these ISR assets low-density, high-demand assets.

There are many options to solve this problem. In the long term, more of such assets can be purchased, making these higher-density assets and allowing more of the demand to be satisfied. It might also be possible to integrate more sensors on existing platforms and, if mechanisms are put in place to enable the collection and exploitation of that data, then satisfy more of the insatiable demand for intelligence. While such options are worth detailed investigation, they are not the focus of the research presented in this document.

Another option for helping deal with a large demand for information is to be more efficient with those assets that are available. By managing the planning and execution processes associated with these assets more efficiently, warfighters will be able to make the best use of these scarce resources. Better processes should also prove useful as more and more assets are integrated into the overall constellation of ISR assets. Without improved methods for planning and execution, it is possible that those responsible for managing ISR assets could simply become overwhelmed. This report will focus on potential improvements to managing the planning and execution of ISR operations.

Another challenge relates to the changing nature of military operations. Historically, the vast majority of surveillance and reconnaissance operations during wartime were planned operations against fixed targets or specified areas. As a result, these operations could be scripted many hours or days before the execution. Current joint and U.S. Air Force doctrine address the use of intelligence assets in a wartime situation and both describe a process that is well suited for deliberate operations: deriving requirements, selecting collections that best meet the requirements, and tasking the appropriate assets to collect in order to satisfy the requirements (United States Air Force, 1999; Joint Chiefs of Staff, 2004). Deliberate processes are ideal for situations where the collection deck for any given day is known well in advance of execution.

However, recent conflicts have highlighted the importance of time-sensitive and relocatable targets. Finding and destroying ballistic missiles were a high priority for commanders in both Operation Desert Storm and Operation Iraqi Freedom. Individual terrorists and leadership targets were a priority during Operation Enduring Freedom. During Operation Allied

Force, high priority was given to destroying small military units engaged in ethnic cleansing and destroying radars associated with the integrated air defenses of Serbia. Against each of these target classes, airpower showed little effectiveness (Vick et al., 2001; Lambeth, 2001; McNabb, 2004). One of the primary reasons for this shortfall was the inability to find and identify mobile and relocatable assets. In order to handle the ISR demands posed by these targets on a rapidly changing battlefield, a new framework may be needed for making the best use of assets against emerging collection opportunities.

This technical report proposes ideas for improving ISR collection planning and execution. As part of an ongoing, larger study on ISR command and control, the thoughts presented here describe a new framework for the tasking and employment phase of ISR operations. Some of the details of this framework are being refined based on continuing research, but we would like to present these ideas to the broader community for comment and discussion. Other portions of research in this project are examining ways to quantitatively model the effectiveness of different methods of managing ISR forces.

CHAPTER TWO

Potential Shortfalls in ISR Resource Allocation

We first describe in some detail the current ISR campaign planning process at the joint and component levels, followed by a summary of observed shortfalls.

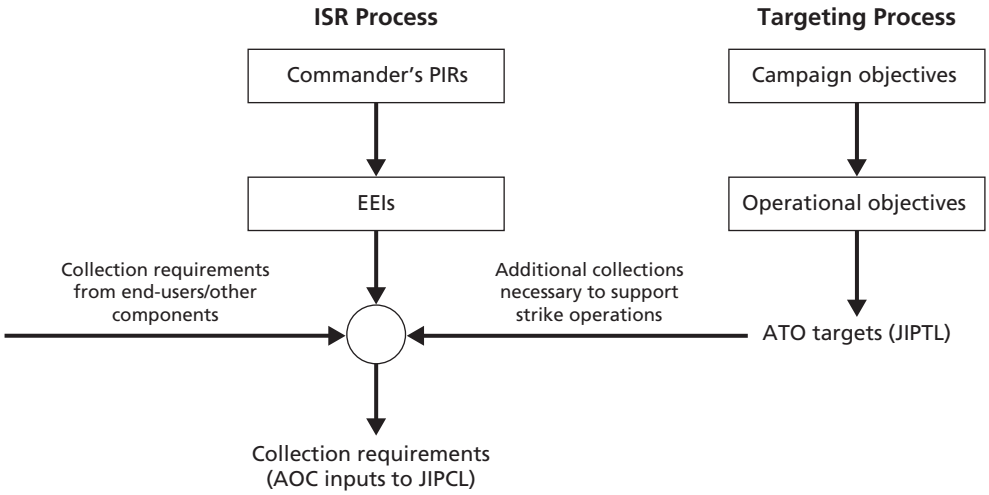
Current Processes

The joint force commander (JFC) is charged with allocating his ISR resources to achieve the campaign objectives. Current joint doctrine for allocating wartime ISR resources starts with the commander's critical information requirements (CCIRs) to support an overall strategy. Those requirements considered the most important are the priority intelligence requirements (PIRs). An example of a CCIR or PIR might be, "Where is the main terrorist training camp?" The pieces of information critical to addressing the PIRs are called essential elements of information (EEIs) and it may be necessary to gather a number of EEIs to answer all aspects of a given PIR. EEIs for our example could include the number and arrangement of features at a suspected site or the volume and content of calls from a particular cell phone. Each EEI may have specific observables tied to satisfying their collection. In our example, observables would include buildings, firing ranges, vehicles moving to and from the camp, or communications intercepts.

Each component, including the air component, is going through this process to generate its own Component Integrated Prioritized Collection List. In addition, in the Air Operations Center (AOC) the Combat Plans Division is generating collection requests to support ongoing strike operations. A simplified, nondoctrinal view of these processes is shown in Figure 2.1. In the AOC, the output of the process forms the basis of the air component's inputs in the joint collection management process. The integrating step of collection management for all forces is performed at the joint task force (JTF) level or may be delegated to a particular service component (Joint Chiefs of Staff, 2004).

The JTF collection manager is tasked with converting intelligence requirements into collection targets to form the Joint Integrated Prioritized Collection List (JIPCL), i.e., selecting specific collections that will service the EEIs and thus answer the PIRs. At the joint level, the collection management process involves integrating and prioritizing requests from all components. Guided by an intelligence strategy, the collection manager must make the best use of limited ISR assets while trading off collection requests from various sources and satisfying

Figure 2.1
Collection Managers in the AOC Are Responsible for Integrating Collection Requests from Multiple, Disparate Sources



NOTE: JIPTL = Joint Integrated Prioritized Target List.
RAND *TR434-2.1*

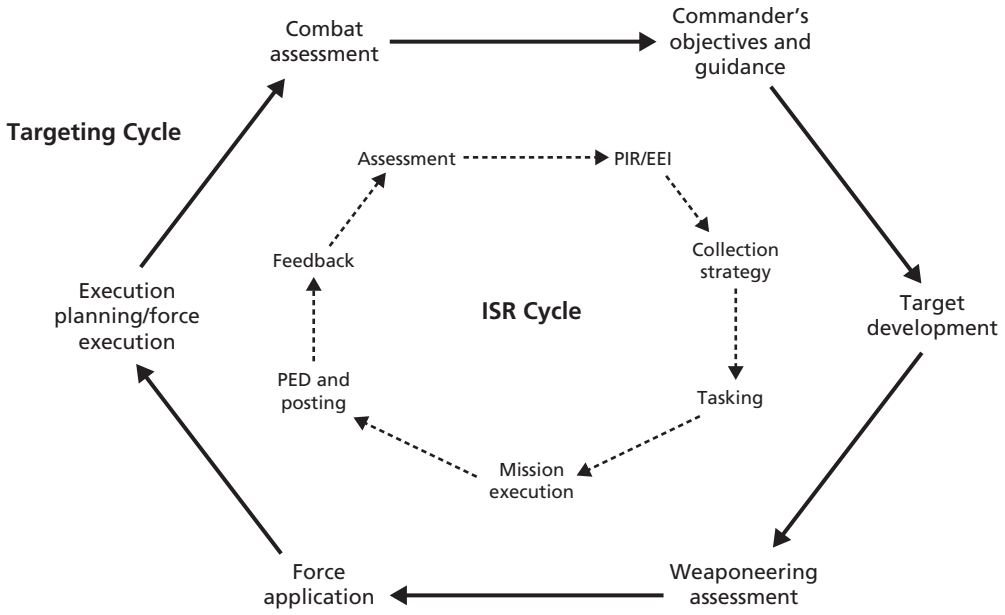
the challenging time constraints associated with wartime operations. The collection manager can allocate forces that are organic to the JTF, but is also able to make requests for services from other national agencies. Joint doctrine specifies that only those collections that cannot be satisfied by organic assets should be forwarded for potential collection by other systems. An example of this situation might be collections beyond the reach of airborne ISR assets that could be filled by national technical means.

To accomplish this matching of requirements, collections, and assets, joint doctrine states that the decision of which requests should be satisfied with the limited assets is made via prioritization. That prioritization is assigned "based on the commander's guidance and the current situation" (Joint Chiefs of Staff, 2004). In most cases, a joint collection management board (JCMB) will be convened by the collection manager and serve as a mechanism for combining and prioritizing the intelligence needs of the various components and the JFC. The JCMB can either be located in a JTF or at the relevant Unified Combatant Command.

Once the requests are prioritized, subject-matter experts determine what collections to plan that should answer the EEIs for priority requirements. The ultimate output of this process is the JIPCL. ISR assets are then tasked to satisfy the JIPCL by collecting on the targets that will satisfy as many requests as possible during the planning process, with emphasis on those with the highest priority. This is typically done by allocating a certain percentage of possible collections to priority No. 1, a lower fraction to No. 2, and so on until all the possible collections have been planned or the entire JIPCL has been collected. A certain number of collection "slots" are also left open on each platform to allow for potential "ad hocs," or unplanned collection opportunities.[1] Figure 2.2 summarizes both the ISR and targeting cycles that occur in support of each air tasking order (ATO) cycle.

[1] It is our understanding that this is the apportionment mechanism typically used in the Planning Tool for Resource Integration, Synchronization, and Management (PRISM)—the collection management software currently employed at Pacific Command.

Figure 2.2
Targeting and ISR Processes Operate in Parallel During the ATO Cycle



NOTE: PED = processing, exploitation, and dissemination.
RAND *TR434-2.2*

During the planning phase of ISR operations, the collection manager has a difficult job. The collection manager begins with the highest-priority requirement and determines how the existing assets can satisfy those requests. Collection system effectiveness is determined by analyzing the capability and availability of existing assets to collect against a specific set of targets. The proper asset for collection against a given target is weighed against the range to target, timeliness, weather, and geography. Those requests given a low priority may simply fall off the collection list. For example, bomb damage assessment (BDA) was assigned a low priority during the combat operations associated with Operation Iraqi Freedom. As a result, very few requests for BDA collections were satisfied (Rhodes et al., 2003). After the campaign, some senior USAF leaders claimed that the lack of BDA was a shortfall of the ISR system, rather than recognizing the situation was the result of a low priority assigned to BDA collections and a lack of ISR assets given the large number of collection requests.

The prioritization process described in Joint Publication 2-01 (*Joint and National Intelligence Support to Military Operations*) not only addresses the importance of a collection; there is also consideration of target dynamics in the prioritization process. For example, page III-12 states, "Collection requirements that are not time-sensitive may initially be submitted at lower priorities in the expectation that such requirements may be satisfied during complementary collection operations" (Joint Chiefs of Staff, 2004). This implies that time-sensitive collections are assigned a higher priority than would otherwise be the case simply so they are completed in a timely fashion. This "gaming" of the priority system is not the most transparent method of accounting for target dynamics.

In practice, operators attempt to use their best judgment in prioritizing the importance of new time-critical targets with respect to existing collections. However, at times the guidance provided in the reconnaissance, surveillance, and target acquisition (RSTA) annex of the ATO is not sufficiently detailed to allow informed decisions to be made by operators at disparate locations.

Shortfalls in the Current Process

In the process just described, collections appearing on the JIPCL are ultimately derived from the JFC's intent. However, once on the JIPCL, it is difficult to trace any individual collection back to the effect that is to be achieved upon collection. PRISM, the Web-based collection management software currently employed at Pacific Command, allows one to associate collections with PIRs. However, according to users of the systems, a detailed understanding of the role of the collection in satisfying the PIR is not included in PRISM.

Few, if any, written linkages exist between top-level priorities and individual collections. In addition, the reasoning process behind collection decisions is often spread through multiple staff organizations in multiple components. As a result, it becomes difficult to identify ties between the top-level strategies and the collection tasks that help to enact those strategies for ISR operations. Furthermore, with the relative importance of requests only distinguished by their position in the prioritized ranking, there is insufficient information to make informed trade-offs between collections. Such shortfalls cause difficulties in both the deliberate planning and dynamic retasking processes.

In a paper published by the Air War College in 2004, then Lt Col Daniel Johnson recognized this problem and proposed implementing a strategies-to-tasks framework (Thaler, 1993) for linking the JFC's guidance to specific tasks via operational objectives. Strategies-to-tasks is the process that starts with broad, campaign-level objectives and links them to operational objectives and finally to operational tasks. By using this framework, it should be easier to understand the contribution of individual collections with respect to the JFC's guidance and to help guide the prioritization process. This should help speed the process of retasking ISR assets, as the trade-offs between targets are more readily apparent (Johnson, 2004). Making intelligent decisions about retasking collection assets is difficult today because it is hard to unravel what is lost at the strategic level by not satisfying a particular collection request.

Such a strategies-to-task planning mechanism is already firmly entrenched in the Strategy Division of the AOC (United States Air Force, 2004). The Air Operations Directive (AOD) provides guidance for those in the Combat Plans Division in a strategies-to-tasks framework. At times, guidance for ISR-related operational tasks to be accomplished is also placed in the AOD, but there is no standardized mechanism for incorporating this information in the existing computational tools used by collection managers. While there are personnel from the ISR Division of the AOC assigned to the Strategy Division considering these issues, better automation could help these divisions work together more efficiently.

Ideally, a commander should be able ensure that his PIRs are being satisfied with the appropriate level of effort rather than simply prioritizing individual collections. It should be

transparent throughout the chain of command why certain collections are being performed and others are not. It should be possible to determine when to replace planned collections with ad hoc collections. Such a method should allow for separating the importance of any given collection from the likelihood of successfully collecting against that target. The utility of a successful collection and the probability of a successful collection are two distinct and separable terms. For these reasons, we intend to expand upon the strategies-to-task framework laid out by Lt Col Johnson to help senior leadership and ISR operators to better plan and execute ISR operations under a framework of centralized control and decentralized execution.

It should be noted that this proposed framework is simply a tool to help operators and decisionmakers with the planning and execution of ISR operations. Like any good tool, this framework is not intended to replace good military judgment. We envision situations where this framework may not be consulted or employed, for a variety of reasons. However, it could be a useful addition to current processes and procedures for planning and executing ISR operations.

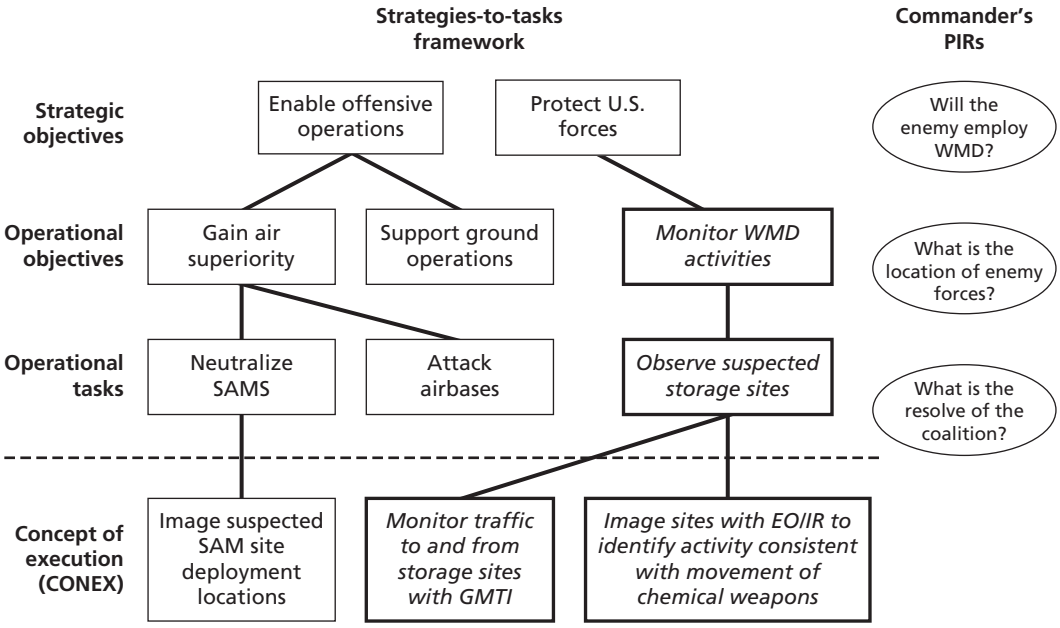
CHAPTER THREE

A Framework for Allocating ISR Resources

A strategies-to-tasks framework is ideal for identifying the complete range of operations that could help satisfy the commander's PIRs. Furthermore, the value could be extended to include links between "finders" and "shooters" through concepts of execution (CONEX) for accomplishing almost any operational task. This framework should also help enable effective decentralized execution based on the guidance given from senior leadership (centralized control). The framework consists of campaign-level strategic objectives, operational objectives, and operational tasks. As noted in Chapter Two, there is already a strategies-to-tasks framework utilized in the AOC—namely, in the Strategy and Combat Plans divisions as part of the ATO production process. The teams that make up these divisions use this framework to create target nominations that achieve the commander's objectives. Note the similarity with the ISR planning process. Both divisions are taking the top-level commander's guidance and forming a list of targets, although in the ISR case it is a list of collections. Rather than the two processes using two different sets of objectives and tasks, we suggest they coordinate their efforts and use a single, unified framework, informed and expanded upon by the commander's PIRs for use in ISR allocations in support of the overall campaign plan.

As shown in Figure 3.1, the top level of this framework is the commander's strategic, theater-level objectives—those that are essential to achieving positive campaign outcomes. Examples of these objectives include top-level statements like "Halt the invasion," or "Protect U.S. and coalition troops." Under each of these strategic objectives is a set of operational objectives to be achieved to help support the top-level campaign objective. These operational objectives will probably need to be expanded upon from the targeting framework to support all of the ISR requirements. For example, "Gain air superiority" and "Monitor WMD [weapons of mass destruction] activity" might be two examples of operational objectives that fall under the campaign objectives described above. This second objective is not one that would be expected to appear in a targeting framework. Instead, it would be added to the framework as a result of a commander's PIR such as "Will the enemy employ WMD?" Furthermore, for these ISR-specific strategic or operational objectives, the EEIs associated with each PIR can easily serve as a guide to appropriate operational objectives or operational tasks. We have noted what might be additional objectives and tasks in the figure with italicized print and thicker borders. Note that in a real-world case there might be 5–10 top-level intelligence requirements with any number of operational objectives and operational tasks under them. The change to current processes here is that PIRs and EEIs guide modifications to a preexisting strategies-to-task framework rather than form the top level of an ISR-unique framework.

Figure 3.1
Commander's PIRs Should Guide Development of ISR-Specific Objectives and Tasks



NOTE: SAM = surface-to-air missile.
RAND *TR434-3.1*

Operational tasks are at the lowest level and could include the following tasks to support the WMD-related operational objective described above, such as "Observe suspected storage sites." In Figure 3.1, we highlight that below each of these operational tasks is the CONEX necessary to actually accomplish the task. The CONEX uses the observables of each operational task, such as "Use GMTI [ground moving target indicator] to monitor traffic to and from suspected chemical weapons sites" or "Take EO [electro-optical] imagery to identify activity consistent with movement of chemical weapons," to guide the specific collections to be performed. Note that we associate a particular sensor type (such as a GMTI or an electro-optical and infrared [EO/IR] sensor) in our exemplary CONEX. Doing so could be optional but does bring advantages. First, some types of sensors may provide more information than others, and so would be preferred. By separating them out, more-capable sensor types can be given higher priority. Second, this methodology easily allows for multiple sensors to be focused on the same target, which may improve probability of collection and enable advanced processing techniques. The disadvantage of this approach is simply the additional workload of generating utility values and managing the large number of operational tasks that may result.

A strategies-to-tasks framework for ISR could be useful for a number of reasons. First, it helps to identify a range of collection strategies for satisfying the commander's objectives. Using this framework will help to identify a range of effects-based options. Such a hierarchical list also makes it possible to trace those tasks at the lowest level back to the commander's intent. Lt Col Daniel Johnson identifies both of these advantages in his paper (Johnson, 2004). An additional advantage of the framework depicted in Figure 3.1 is that the collection requests

driven by targeting and intelligence needs are both present. Rather than requests for ISR support being passed "over the transom" from the Combat Plans Division, the ISR Division now knows exactly what the planners are trying to accomplish and has a transparent audit trail for how they support top-level objectives. In addition, the different communities planning future offensive operations and future ISR operations will be able to better "speak the same language," allowing better integration across the AOC. The final advantage to this hierarchical framework is that it simplifies the process of assigning priorities to various collection tasks if a utility metric is used at each stage of the process.

Assigning Utility to Objectives and Tasks

Current doctrine speaks of assigning priorities to requirements. The problem with a simple ranking or prioritized list is that it doesn't allow one to identify the relative worth of a higher-priority collection when compared with one or more lower-priority collections. Furthermore, because no utility function has been assigned to the objectives, it is difficult during the execution phase to weigh various potential ad hoc taskings against planned tasks. For example, should two low-priority, time-sensitive collections be substituted for a single preplanned, higher-priority collection? By assigning utility values or relative weights to all potential collections, better guidance can be provided for those making decisions about retasking sensors or assets.

At this point in the development of our utility framework, one should only consider the utility of a successful collection when assigning utility values. Later, we will take into consideration whether a collection can be made with the available assets and the probability of a successful collection. Both the utility of the collection and the probability of making a *successful* collection will be considered when making decisions about planning collection strategy and making decisions about retasking assets. However, at this stage we are only concerned with identifying the utility of various collections.

The process starts with the campaign-level strategic objectives. A set of objectives is defined, most likely at the JFC level, and weights corresponding to the relative importance of these tasks are then assigned. The Strategy Division should certainly play a role in this effort. The sum of weights across all the campaign objectives would be normalized to 1. Note that we are *not* making resource allocations at this stage but rather identifying the utility of achieving these campaign objectives. Initially, these utilities will come from information generated by intelligence preparation of the battlespace (IPB), but will evolve over time as the campaign progresses through various phases and our understanding of the adversary improves. In fact, preconflict deliberate planning could map out the weights of each objective and task for every campaign phase.

Next, a set of operational objectives that helps to achieve each campaign-level objective is identified. This task is best performed at the command level, advised by subject-matter experts that understand adversary behavior. Good IPB is needed to prepare a set of operational objectives to best serve campaign-level objectives. Weights are assigned according to the contribution of each operational objective toward accomplishing campaign-level objectives. Again, the

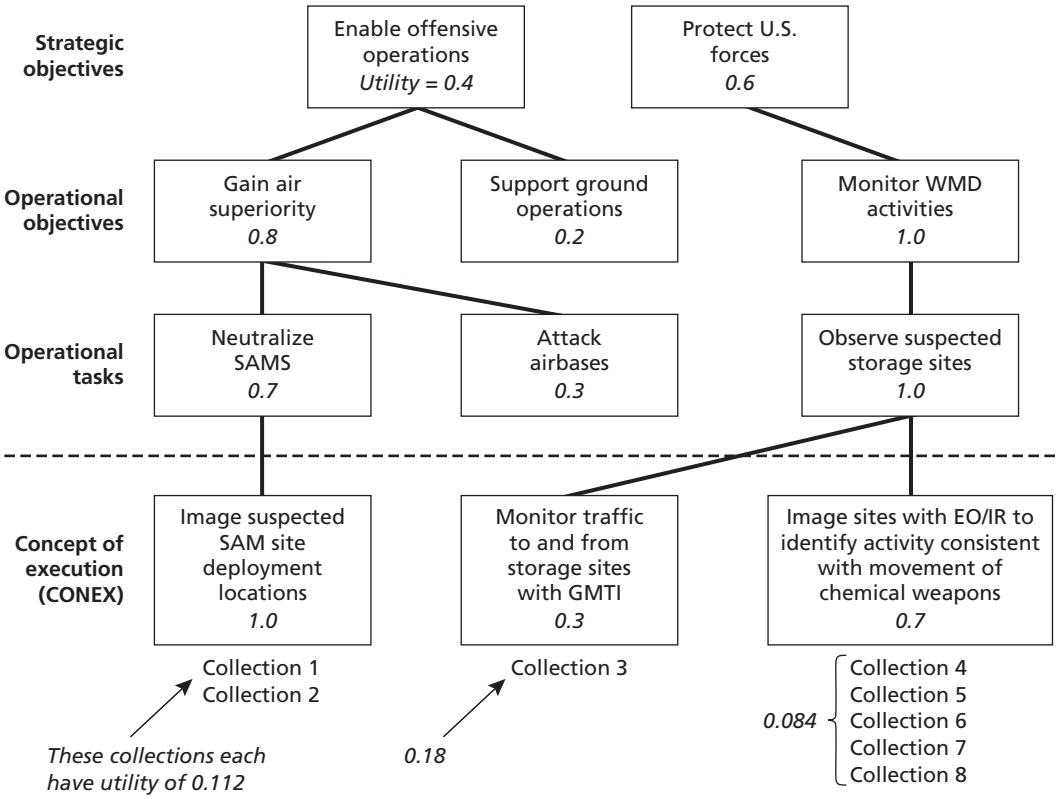
reader is reminded that we are not assigning level of effort at this stage. We are simply identifying the contribution of each successful operational objective to a campaign objective. The weights of each group of supporting operational objectives under a single campaign objective should be normalized to sum to 1. Since the ISR Division will be utilizing parts of the framework from the Strategy and Combat Plans divisions, their guidance on utility values is important, although the ISR planning process may be using different weights at the lower levels than the targeting process since they could have a somewhat different set of tasks (those that are intelligence-only, for instance).

Finally, at the lowest level, a set of operational tasks that support each operational objective should be defined. All of the collections that could end up on the JIPCL will eventually be associated with an operational task. As before, each operational task should be assigned a weight that corresponds to the contribution of a successful task toward its corresponding operational objective. All the tasks under an objective should sum to 1. The weights assigned at each level of the hierarchy should be evaluated on a regular basis (i.e., every ATO cycle), along with consideration of any new objectives or tasks. The JCMB could be a good forum for this discussion. If the CONEX under the tasks contains several approaches that could compete for resources, weights can be applied here as well.

By multiplying out the weights through the hierarchy for each of the tasks (see Figure 3.2), the *total utility* of successfully accomplishing a task can be quickly identified. In this example, the collection utility of 0.112 under the "Image suspected SAM [surface-to-air missile] site…" task is obtained by multiplying the strategic objective utility of 0.4 ("Enable offensive operations"), the 0.8 utility of the operational objective ("Gain air superiority"), and the 0.7 utility of the operational task ("Neutralize SAMs"), and finally by dividing by 2 for the two collection targets that support the task. The total utility is a campaign-level measure of the relative utility of individual tasks. Likewise, if all of the collections associated with a task are assigned a utility summing to 1, the total utility of each individual collection can be found by multiplying by the task utility. The additional workload of assigning weights to all of the objectives and tasks should not be onerous given that all of them are already placed in rank order in today's process. Additional thought will certainly be necessary to decide how much more important higher-ranking objectives are than lower ones, but good planners already consider these factors. The advantage here is that this thought process will be formalized and made transparent to high-level commanders, their ISR planners, and others who request ISR support.

Note that objectives with many tasks or tasks with many collections could result in lower total utilities for each collection since the sum at each level must total 1. In the example in Figure 3.2, while Collection 3 is associated with a lower-priority element of the CONEX than Collection 4, the fact that the entire task can be satisfied by that single collection is reflected in the higher-utility value associated with Collection 3. Also, note that there may very well be duplicate collection targets that satisfy more than one operational task. In this case, the utilities for each occurrence can simply be added together to produce a higher utility. This emphasizes the efficiency of collecting on targets that help achieve multiple objectives. When all of the utilities have been calculated, the result should be a prioritized list of targets.

Figure 3.2
Notional Target Utility Values Calculated



There are several benefits to this formulation for computing utility. First, there is a clear and direct link for the value of each individual operational task and collection at the lowest level all the way up to strategic objectives. When tasking and retasking decisions are made, it is possible to quickly calculate the comparative values of various collections. Second, the hierarchical nature of the process makes for a natural division of labor across the chain of command. Senior leadership can remain focused on the relative importance of top-level strategic objectives and ensuring that the utility values are correct, while specialists and subject-matter experts can work on operational tasks and the collection targets that will support them. Third, the process is able to quickly accommodate changes to a commander's guidance or unexpected adversary behaviors. When changes are made to the utility weights at the campaign level, recomputing the total utility for each of the operational tasks can be done very quickly, leading to a rapid reprioritization of the collection list. In addition, changes to collections to improve the accomplishment of operational tasks or objectives during the campaign can be easily performed. This factor is important as it preserves the importance of military judgment for forming a prioritized list of targets.

One other, less quantifiable advantage of this framework is that it helps to emphasize the operational level of ISR strategy, planning, and collection management. By allowing the intelligence staff to plan against the same objectives and tasks used by the strike planners, the two

components in the AOC should more easily integrate and begin to see new opportunities for mutually supporting each other.

Probability of Successful Collection

The importance of an individual collection is the primary factor considered by collection managers when planning ISR operations. However, collection managers also have other potential factors to consider when planning operations, such as

- poor weather between an EO/IR sensor and the target
- low grazing angle
- target relocation
- terrain obscuration
- effective concealment, camouflage, and deception
- short duration, rare signal emissions
- encrypted signals.

These individual considerations fall into the category of factors that affect the probability of achieving a successful collection against an individual requirement.

In this section, we propose a method for incorporating the probability of successful collection into the strategies-to-tasks utility framework. Despite the difficulties in determining extremely accurate probabilities for each collection, including estimates of the effect of such factors may aid in the creation of a more-realistic collection strategy. Without accounting for such effects, the prioritized collection deck arrived at by the previous method will be more of a collection "wish list" rather than an operationally relevant list.

After utilities have been assigned to each operational task, the next step in the planning process is to assign the available collection assets to maximize the expected collection utility for that day. Using the process described in the previous section, we assign utilities to each operational task. Then, we estimate the probability of successful collection based on the system capabilities and thorough knowledge of how the adversary behaves. While the probability of successfully collecting against any single target can't be known exactly, it should be able to be estimated. In addition, while the probability of successfully satisfying a single request may be low based on a single collection, that probability might be increased by making multiple collections with a single asset, by persisting over a given target area, or by performing collections with multiple sensors or platforms.

The expected utility of any given collection is defined by the product of the total utility of the probability of success with the probability of success given that collection. Mathematically, this is

$$E(j) = U(j) \times P(j)$$

where $E(j)$ is the expected utility of collection j, $U(j)$ is the calculated utility of collection j, and $P(j)$ is the probability of successfully achieving collection j.

During the deliberate planning process, collection managers should strive to form a collection plan that maximizes the expected total utility for that day. What we mean by this is that the collection managers should strive to maximize

$$\sum_i U(i) \times P(i)$$

where the set of collections, i, is limited by the number of assets, types of sensors, and time. While this may seem to be a difficult optimization, remember that it is likely that a certain number of our collections may simply be infeasible (because of poor weather or long range, for instance) and therefore have zero probability of success. Those collections should be removed from consideration prior to the optimization process. Furthermore, it is not necessary that an exact probability of collection be assigned to every target. Simple categories such as high, medium, and low with associated numerical probabilities such as 0.9, 0.5, and 0.1 might suffice for many collections. If the operational tasks are defined as a function of sensor type, the tools implementing this methodology could easily be constructed such that targets satisfying multiple operational tasks with multiple sensors get a boost in their probability of collection.

Effect of Methodology on Deliberate Planning Processes

The ultimate output of the strategies-to-tasks framework laid out here is the daily collection deck for each ISR platform. As just mentioned, the objective is to maximize the expected utility of all the collections. There are many options for forming a collection strategy with this methodology. With the utilities and probabilities of collection in place, a prioritized list of collection targets can be calculated. Planners could simply start at the top with the highest-expected utility collections and work their way down until all of the collection capacity had been tasked.[1] Targets with high priority but low probability of collection (ballistic missile launchers, for instance) will not consume excessive collection resources. The disadvantage to this approach is that in a capacity-limited case, it is possible that targets supporting some operational tasks might never be serviced. This could also be a problem with targets having a very low probability of collection. If situational awareness, rather than collection of information against specific targets, is desired, then a task associated with gaining situational awareness about a particular area could be defined and assigned the appropriate utility in the framework.

Another method would be to skip the final step of calculating the utility of every target and simply calculate the utility of all of the operational tasks. Since the sum of these utilities must add up to 1, the utility can be converted directly into a percentage of collection capacity. For the example in Figure 3.2, the "Image suspected SAM" task would get 22.4 percent

[1] Once all the collection requirements have been ranked, an initial step would be to separate out those to be collected by different sensors and platforms since they do not compete with each other for collection capacity.

of the collection deck, the "Monitor traffic" task would get 18 percent, and the "Image sites" task would get 42 percent.[2] This method has the advantage that every task will be collected against, but the disadvantage that targets associated with higher-priority tasks may be rejected in favor of lower ones. With our example, if the number of targets associated with "Monitor traffic" requires more than 18 percent of the capacity, should they be rejected in favor of some for the "Image sites" task? Such decisions are probably best left to the judgment of the planners. A disadvantage of this approach is that probabilities of collection are ignored since they are attached to individual collection targets, not operational tasks. The advantage of pursuing a utility methodology is that all the information is available for intelligent decisionmaking.

The most likely tool for implementing this framework in the deliberate planning process is PRISM (the Web-based Planning Tool for Resource Integration, Synchronization, and Management). Currently used to integrate collection requests from the JFC and various components and, with other tools, generate the daily collection deck, it would be a reasonable modification to add the strategies-to-tasks and utility functionality discussed here. Each collection target would be attached to higher-level operational tasks and objectives instead of PIRs. The utility functions attached to each of these would be updated every day and used to calculate the task and collection target utilities. The desired methodologies for building the collection deck could then be implemented as algorithms within PRISM, available for use by the collection planners.

Effect of Methodology on Dynamic Retasking Processes

During execution of the collection plan and the day's ATO, sensor assets are routinely retasked in order to collect against ad hocs and other unplanned collection opportunities that may present themselves. Guidance for these retaskings comes from the RSTA annex of the ATO, which lists the commander's priorities for collection each day and often specifies in which situations assets can be retasked. An example of such a collection would be the location of a downed pilot, to support a search and rescue operation. Since most of the capacity of collection platforms is filled during the deliberate planning process, changing the plan for an ad hoc collection may require losing other collections. The added step of moving a collection platform could result in losing even more planned targets. Retasking decisions are made on a regular basis by the staff of the ISR Division on the AOC floor, operators in the Distributed Common Ground Station, and occasionally by sensor operators themselves. All are doing their best to interpret the commander's intent but have little quantitative information available to them to determine whether new collections are more important than planned ones.

With this strategies-to-tasks utility framework, when making decisions about retasking assets, one can use a relatively simple mathematical test. If the expected utility of the new ad hoc tasking is higher than the expected utility of the original tasking(s), then that retasking should be performed. Mathematically, this means retasking should be performed if

[2] These do not add up to 1 since we have omitted some operational objectives and tasks from our example.

$$\sum_i U(i) \times P(i) \quad > \quad \sum_j U(j) \times P(j)$$

where the tasks, *i*, are associated with the ad hoc tasking and the tasks, *j*, are associated with the originally planned tasking. Ad hoc taskings should only result if the new collection utility and probability of success give, overall, a better solution to addressing the commander's objectives.

One benefit of this framework is that it makes retasking decisions relatively straightforward. Take a leadership target, for example. Searching a city for this target with EO sensors would have a low probability of success without any other supporting information; therefore, the expected utility, which includes probability of success, associated with that task would be very close to zero. An unmanned aerial vehicle equipped with EO sensors would probably be put to better use performing other tasks on the battlefield, even if the task of finding the leader has a high utility associated with it. Now, say one gets a good cue from another source that a leadership target is in a given village. At this point, the calculus associated with retasking changes because of the higher probability associated with the target. Good ISR operators and collection managers already utilize this thinking in their decisions, but our proposed framework helps standardize the process.

To implement this retasking methodology, the ISR cell on the AOC floor must have access to tools capable of displaying and recalculating the relative utilities of the planned collection deck and potential ad hoc collections. This requirement highlights the need to be able to rapidly place a previously unknown target into an operational task and to assign a probability of collection. To do this, target categories must be planned for in advance with operational tasks in the framework. An example might be the retasking required to accomplish the operational task of rescuing a downed pilot. Part of the CONEX for this task would be to "Image site of downed aircraft," which has no collection targets assigned to it for deliberate planning purposes but would have a high utility attached so that ad hocs could be quickly accomplished. Other emerging targets such as missile launchers or leadership targets would probably already have appropriate tasks in the framework.

In addition to the utility functions, the AOC staff also needs tools to visualize the real-time location and sensor capabilities of the available ISR platforms in order to choose the most appropriate system for retasking. This functionality could be a part of the Collection Management Mission Applications, but these tools must be fully integrated into the AOC to provide the needed information rapidly enough. In addition, these tools need to be linked to tools and output of the Strategy Division used to plan the strategies-to-tasks frameworks associated with air operations.

CHAPTER FOUR

Future Work

In our current research, we have applied this strategies-to-tasks framework to the problem of allocating imagery assets and sensors against collection requests associated with a real-world exercise based in the Pacific Command area of responsibility. While such a framework could be employed for any type of asset (ground-based, airborne, space-based, etc.) or any type of intelligence (electronic, imagery, etc.), our initial goal is to develop techniques and procedures for utilizing this framework in the AOC environment. The AOC typically performs planning and manages the execution of airborne ISR platforms, so our initial goal is to focus on those assets.

This management framework has been built into our ISR modeling environment, which allows us to evaluate how various measures of effectiveness change when utilizing this framework to plan operations. However, the main goal of employing strategies-to-tasks in managing the planning and execution of ISR operations is to allow the human planners in the ISR Division of the AOC to be more effective and efficient in their operations. By utilizing this framework, personnel in the ISR Division should be able to think beyond just satisfying collection requests that are submitted. They should be able to think more broadly about the effects of their ISR operations and the connections of those effects to campaign-level objectives.

In order to further develop and evaluate this framework, we will need to implement it in an operating AOC: either in real-world operations or as part of a large AOC-scale exercise. Feedback from commanders and those in the ISR Division will be needed to inform us about the utility of this framework. It is hoped that this framework will allow ISR assets to be utilized to greater effect.

As the time of writing this document, there are plans to implement and test this framework in the Joint Expeditionary Force Experiment ’08. Such a large-scale test of this method will require us to further refine certain aspects of this methodology, but it should allow us to evaluate the feasibility and desirability of implementing this framework as part of standard ISR Division procedures.

CHAPTER FIVE

Concluding Remarks

To assist in moving ISR planning and execution forward from a fixed target and deliberate planning focus to one centered on emerging targets, we propose enhancing the collection management process with a strategies-to-tasks and utility framework. By linking individual collections to operational tasks, objectives, and the top-level commander's guidance with relative utilities, planning for the daily intelligence collections and real-time retasking for ad hoc ISR targets will be enhanced and better use will be made of high-demand, low-density ISR collectors. When current tools are modified to provide this information and the system is evaluated in operational realistic testing, planners will be able to link collection targets to top-level objectives for better decisionmaking and optimization of low-density, high-demand collection assets. Similarly, on the AOC floor, intelligence officers will be better able to deal with time-sensitive, emerging targets by rapidly comparing the value of collecting an ad hoc collection with the value of collecting opportunities already planned. In order to handle the ISR demands posed by the rapidly changing battlefield of the future, this new, more-capable framework may be needed for making the best use of intelligence capabilities against emerging collection opportunities. Future research will focus on quantifying the advantages of this approach in comparison with the current process.

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