Conceptual Description:
The Sophisticated Automatic Policy-Generation Executor (SAGE) Tool*

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Abstract

This paper describes a concept for a tool (the SAGE: **S**ophisticated **A**utomatic policy-**G**eneration **E**xecutor) that will provide semi-automatic development and implementation of information policy to assist military commanders in meeting their operational requirements. The concepts presented here address the problem of deriving organizational information management policies from mission concepts and provide a mechanism for commanders and their staffs to articulate information policies appropriate to their roles and echelons within the organization. It is suggested that generation of these information policies can be facilitated by a web-based "wizard." This wizard (the SAGE) would assist the commander and staff in completing task templates relevant to mission concepts and plans, and then derive information policy elements for review and execution. The tool would retrieve and fill out existing task templates to the degree feasible and query users only to the point that gaps in task templates need to be filled. The tool would also monitor for changes in operational circumstance to trigger adaptation of supporting information management policies. A generic example of the method and a conceptual case study approach are provided. Additional applications of the concept to support information assurance activities, e.g., intrusion detection and response, are also explored.

1. Introduction

This paper describes a concept for a tool (the SAGE: **S**ophisticated **A**utomatic policy-**G**eneration **E**xecutor) that will provide semi-automatic development and implementation of information policy to help military commanders meet their operational requirements. The SAGE concept is derived from the Information Policy Manager (IPM) Layer of DARPA's Agile Information

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* This paper results from work performed under the direction of Chris Miller and James P. Richardson at the Honeywell Advanced Technology Center in support of the Defense Advanced Research Projects Agency's (DARPA) Agile Information Control Environment (AICE).

Control Environment (AICE). The concepts presented here address the problem of deriving organizational information management policies from mission concepts and provide a mechanism for commanders and their staffs to articulate information policies appropriate to their roles and echelons within the organization. It is suggested that generation of these information policies can be facilitated by a web-based "wizard." This wizard (the SAGE) would assist the commander and staff in retrieving and filling out task templates relevant to mission concepts and plans, and then derive information policy elements for review and execution. A generic example of the method and a conceptual case study approach are provided.

The goal of this paper, to introduce the concept for the SAGE, is achieved in the following sections:

- *Description of the Problem*, this first section briefly describes the need for the SAGE.
- *Description of the Information Policy Management (IPM) Layer*, explains the concept for the IPM layer of the AICE, which will use the task templates produced via the SAGE.
- *Issues in Defining Information Policy Elements*, discusses the major issues that affect the development of SAGE.
- *A Wizard for Generating Information Policies*, describes how the SAGE would be used.
- *Information Usage Activities*, describes the information management and usage model to be used in constructing task templates for the SAGE.
- *Construction of a Task Template Library*, discusses the creation of a task template library based on information usage activities.
- *A Conceptual Case Study Example: JSTARS Deep Strike Targeting Scenario*, provides two Task Template examples to show how information management activities can be used to guide the construction of task templates.

2. Description of the Problem

Effective mission performance across the range of military operations is dependent upon appropriate information exchange within and between all organizational levels. A basic concept in environments such as the Agile Information Control Environment (AICE) is that information exchanges should be driven by dynamic operational requirements and information exchange policies that are explicitly and implicitly directed by the commander. Further, implementation of the commander's information policy spawns new subsets of information policies throughout the organization to enable each echelon to accomplish its mission requirements. This results in organizational information policies at multiple levels: policies specific to the commander's intent and supporting policies that facilitate meeting commander's intent at subordinate levels. With current capabilities, translating the commander's mission concepts into enabling information policies and disseminating and implementing them throughout the organization would be an ad hoc and time consuming process. A tool is needed to rapidly translate mission requirements into enabling information policy, and to implement that information policy at all operational echelons.

3. Description of the Information Policy Management (IPM) Layer

The **S**ophisticated **A**utomatic policy-**G**eneration **E**xecutor (SAGE) is proposed as an evolved concept emphasizing increased use of artificial intelligence in the form of a smart "wizard." The basis of the concept is derived from the Information Policy Management (IPM) Layer of DARPA's Agile Information Control Environment (AICE) whose purpose is to capture and represent commanders' policies for information exchange in a specified mission environment, including the use of their communication and information resources. Essentially, the IPM layer translates commanders' concepts about how they wish to conduct a mission into parameters that are used to control the flow of information over the networks that support the mission. The commander develops a mission plan, which is used to define an information policy for the mission. This information policy is then used to determine the importance of various information exchanges. The current design for the IPM layer of AICE[1] calls for the creation of "policy elements" that define the importance of classes of requests for information. A matching process searches the commander's policy (set of policy elements), finds the policy element that best matches the source, destination, and exchange characteristics (information content) of the information exchange, and assigns an importance to the exchange request based on the importance specified in the matching policy element. Figure 1 provides a simple illustration of this concept. The importance of a request determines the resources that will be allocated to transmit the information and to generate and transmit responses to it.

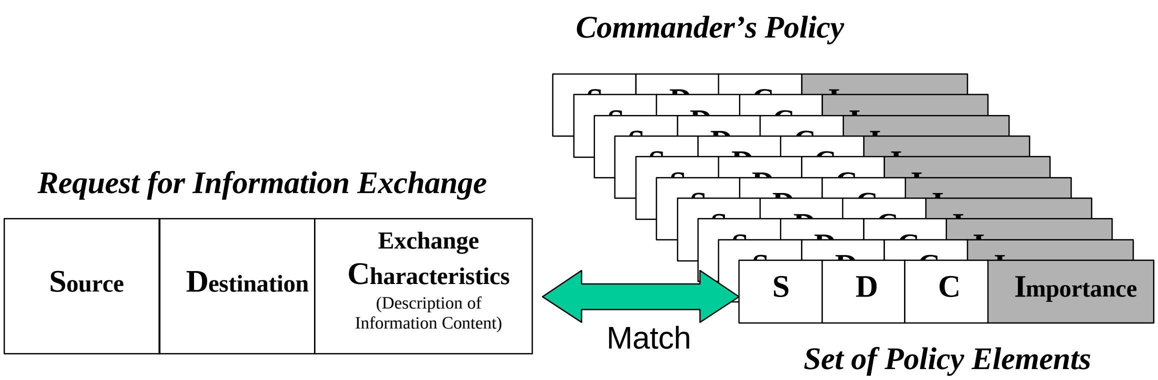

Figure 1. Determining the Importance of a Request for Information Exchange by Matching Against a Set of Policy Elements

4. Issues in Defining Information Policy Elements

We see several major issues in developing the policy elements as illustrated in Figure 1. First is *determination, adaptation, and utilization of the best typology for sources, destinations, and exchange characteristics (information content).* To create policy elements we will need to specify types of sources, types of destinations, and types of information content. The sources and destinations for each exchange must relate back to the network for which an environment similar to the AICE is managing the information flow. An important issue will be level of granularity with which sources/destinations will be specified since this influences the level of granularity at which task templates will be developed. The typology for exchange characteristics

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[1] Based on Evaluation Plan for IPSO FACTO, Chris Miller, July 29, 1999, and The IPM Layer of AICE (Slide Presentation), Chris Miller, Harry Funk, Jim Richardson (undated).

(C) must add value in determining the importance of the exchange, i.e., the value of the C parameter is that it adds information (over and above the source and destination parameters) that improves the ability of a device like the IPM to set the importance of the exchange.

The second major issue is the *method for assigning importance to S-D-C classes* to create a policy element. The importance of the type of exchange must reflect the importance of that exchange for the mission task and should also reflect the utility of the information at each operational level. One method is to assign an importance directly to mission tasks and have all of the policy elements associated with that task inherit the importance of the task, assuming policy elements are completely contained within tasks. Another method is to determine both intra- and inter-task relationships to determine implications for assessment of task importance. This requires a fine-grained and sensitive method for assigning importance to S-D-C classes. The method should also take into account mission cycle, timing, timeliness requirements for the information exchange, the role or function of the user, and changes in the destination of information as tasks are redistributed during the mission.

The third issue concerns the *implementation of the information policy* throughout the organization. The commander's information policy will be broadly stated and reflect an operational perspective. To successfully implement the broad policy, each of the supporting organizational elements must develop supporting information policies appropriate to their perspective since each organizational element will have a different prioritization scheme based on its role and specifically assigned tasks. As the commander's operational intent is translated into supporting policies, a hierarchy of information policies results. A means to determine and filter information exchanges is necessary to ensure that each organizational element receives and appropriately processes its required information in a way that reflects its relevance to that element.

A fourth issue relates to "*importance cycles*." As a mission evolves over time, changes in resource availability, increased familiarity with the operational environment, and changes in operational circumstance will cause changes in priorities and associated importance of tasks relative to mission objectives. These changes in priorities will result in changes in assessed importance of information that will vary differently within and between echelons. Information policies must adapt in response to these changes. This requires a tool to determine when and how to implement time-sensitive changes to policy. One approach is through a "wizard" that functions both to develop an initial information policy and to monitor operational cycles and their effects throughout the organization for "triggers" to adapt information policy to changed circumstance with minimal manual input from users. This wizard would have to be sensitive to micro-policies at each echelon and relate them to the macro-policies that are established at the command level, e.g., a change in priority or importance for a given type/piece of information. Figure 2. represents the relationship between mission and importance cycles.

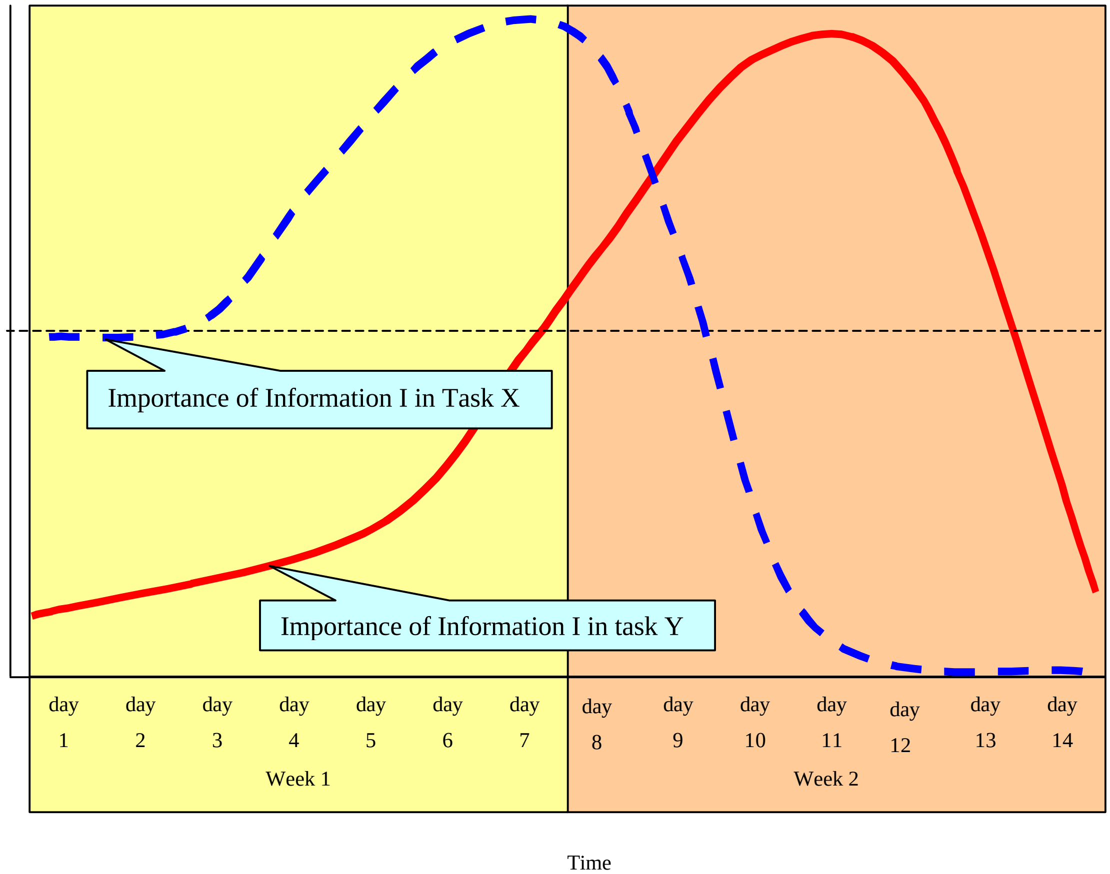

Figure 2. Relationship Between Mission And Importance Cycles

The complex nature of information policies and mission tasks highlights the importance of a fifth issue: creating simple, practical, *human-centered tools for developing information policies* and implementing them. It is not realistic to ask the commander to think about the mission in terms of connections between nodes in a network, and to directly specify a policy that is made up of S-D-C-I policy elements. Neither does it seem reasonable for the commander to explicitly develop supporting information policies at each organizational level. In line with the IPM concept, the SAGE concept calls for the commander to develop a mission plan at a high level that specifies the tasks to be accomplished in the mission, and the creation (through a process yet to be defined) of a set of policy elements based on those tasks. These policy elements will be developed in greater detail as subordinate organizational elements further translate mission tasks and the commander's information policy into supporting information exchange requirements appropriate to their level and function. It is also important to note that the language employed will be common to the operational environment. We address this issue in terms of a "task template library" concept in the next section.

Together these issues raise a question as to the level of granularity with which tasks will be decomposed versus the granularity with which source and destination types will be specified in the policy elements. The source and destination typology must be at a level that is useful to SAGE, i.e., a level that is useful for controlling network traffic supporting a multitude of tasks.

The tasks must be at level that is meaningful to commanders and their staffs as appropriate to their role in the organization, but not so detailed as to be intractable.

Depending on the level of granularity of sources/destinations and tasks, Figure 3 shows possible interactions of S/D typology and tasks. Although it is possible that there will be only one source-destination link between two tasks (as shown at the top of Figure 3), it seems more likely that there will be multiple S/D links between tasks, as shown in the lower example. Any method for creating S-D-C-I policy elements must take into account the existence of multiple links across and between tasks. Additionally, intratask dependencies on information completeness must be addressed.

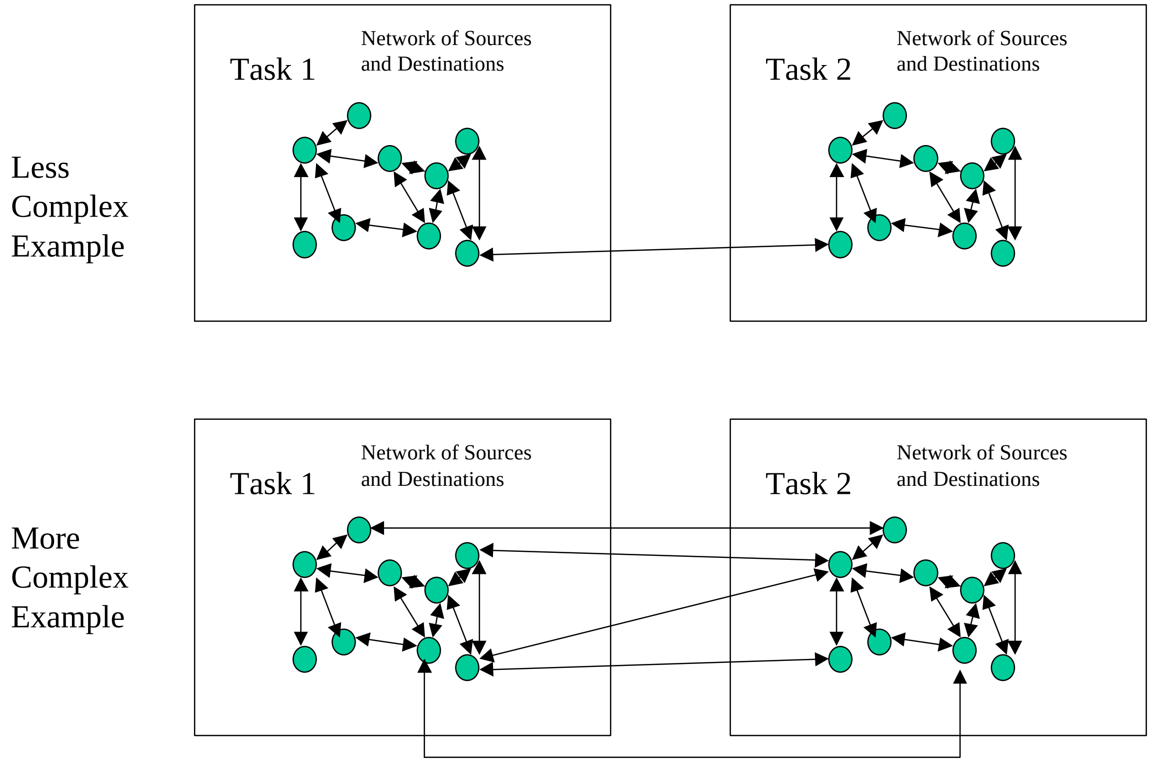

Figure 3. Example of Possible Relationships (Communication Links) Between Sources/Destinations and Tasks at Different Levels of Complexity

5. A Wizard for Generating Information Policies

As is current practice, we envision that the commander and his/her staff will create or modify an operational plan (OPLAN). Then, with the assistance of the SAGE, information policies appropriate to the requirements of the OPLAN will be derived. As mission planning continues, the SAGE will scan a library of task templates and associated information policies for those relevant to the plan. It will attempt to fill in the templates from extant data, and then present the results of these partially populated templates to users. The SAGE may elicit the remaining data for the template from users by presenting questions. It will then derive information policy elements, present them for review and implement them. Presentation of the results will be in a format selected by the user, i.e., relationship diagrams, process flows, elements of task templates, or detailed task templates.

We recognize that the complexity and detail of executing the information usage activities (as described in the next section) will vary with operational tempo, mission phase, and other factors. This requires that the SAGE recommend revisions as the mission evolves. In addition, the process will have a hierarchical aspect. As policy elements are defined at the highest level of command, the SAGE will present the queries necessary to complete increasingly detailed task templates to subordinate echelons, and it will in turn generate information policy elements based on the completion of those templates.

The workload with respect to the quantity of information input to complete the task template at each echelon should be equivalent, i.e., no echelon should be overwhelmed by a requirement to complete/update excessive task templates. The content of the task template at each echelon should focus on the function/role of that echelon and reflect superordinate information policies defined in broader terms.

Ultimately, the information policies that the SAGE produces from the task templates at various organizational levels will be aggregated to provide a coherent organizational information policy articulated at appropriate levels of detail. Once established, the IPM layer will monitor for changes in information policies at all organizational echelons. These will trigger the system to request required or supporting changes at other levels. The degree of automation of the tool to detect and trigger changes in information policy may vary based on user preference at each level, i.e., a range from fully manual input of information policy changes via task templates to a highly automated set of user defined rules that allow the SAGE to make and report changes. The goal will be to ensure that information policies throughout the organization are coherent and responsive to changes in commander's intent, mission cycles, and importance cycles. However, it is not envisioned that population of task templates and development of associated information policies will be an impediment to the organization's ability to act without a complete set of task templates.

6. Information Usage Activities

We propose that there is a set of "information usage activities" that are common across tasks and that can be used in developing the templates with which the SAGE operates. This in turn should help to specify the policy elements that the SAGE generates.

Mission tasks have seven underlying information usage activities — filter, dynamic integration, static integration, transform, store, seek, and disseminate — which we define below. These activities provide a structure for the templates used to develop information policy elements. Specifically, they enable us to define questions that must be answered at each echelon to define the information policies and supporting policies. These questions may serve as the interface for the SAGE, prompting users to provide data that is not available in databases. The information usage activities and their associated questions enable the system to ascertain how information is acquired, how it is used, and how it is disseminated in each task. They help us to learn the source, destination, characteristics, and importance of information exchanges for the task from the users' perspective. They also provide a structure that ensures that we capture all of the important information exchanges in the set of policy elements developed for each task both vertically and horizontally across all organizational echelons.

The seven information usage activities constitute a model of information management and usage, as illustrated in Figure 4. This model has similarities to, but expands on the [Wolf, *et al*., 1996]

Information Management Model. We suggest that these information usage activities are present, at varying levels of detail and importance, in many, if not all, military mission tasks[2].

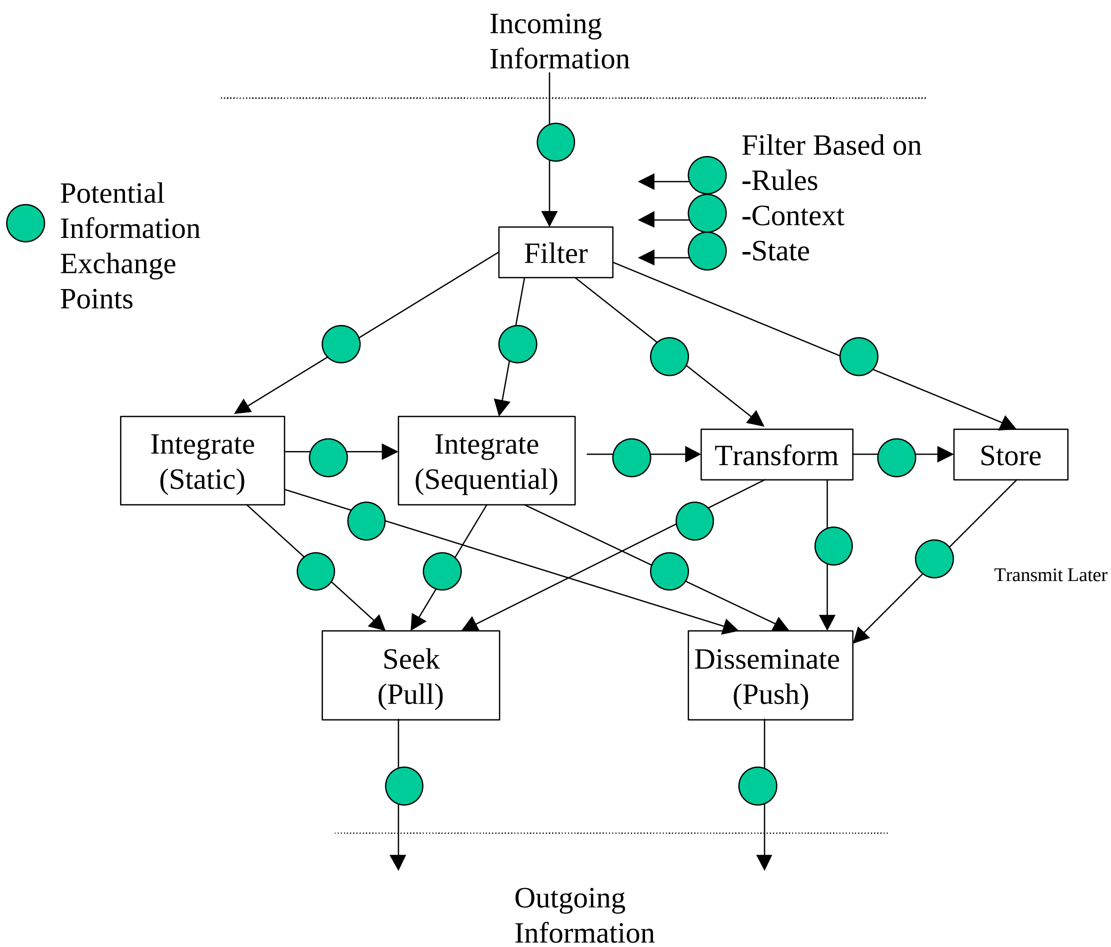

Figure 4. Potential Information Exchanges for a Task

Information Filtering

Not all information received is of equal usefulness or importance; with the assessment of utility dependent upon the user/receiver/sender's role and tasks in the organization. Filtering is the process of deciding what to do with incoming information when some of that information is irrelevant, i.e., when information available is greater than information required. Filtering of information can be done in a number of different ways, including:

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[2] Information may be exchanged at many different points, both within and between tasks, and these exchanges may or may not involve the communication network that is being managed by AICE. There may be multiple sources and destinations, different types of information content, and different importance levels for each of these exchanges, i.e., multiple policy elements that apply to each of the exchange points shown in Figure 4. Obviously, only those exchanges that occur on the AICE-controlled network are of interest for setting information policy.

- Rule-based (parametric) filtering. Information may be filtered based on source and time, e.g., discarding all messages older then 24 hours or discarding all messages from a source known to be unreliable. This is a relatively simple type of filtering.
- State-based filtering. Information may be filtered out based on the state of the entity receiving the information, e.g., the person to whom the message is directed may be in a state of high workload and unable to attend to the information, or the computer receiving the message may have gone down.
- Context-based (situational) filtering. Certain information may be filtered out as irrelevant because it is unrelated to current plans or goals. This is a complex filtering method requiring extensive information and understanding in order to apply the filter.

Filtering can involve many different types of information exchange. Most obviously, information is sent on to other activities (integration, transformation, storage) after it passes through a filter, and these exchanges may or may not involve sending messages over a communication network relevant to an environment such as AICE. Dependent upon the filtering rules applied, alternative candidates to receive information may be identified. Less obviously, information exchanges may be needed to support the filtering process. For example, information on current sensor reliability may be needed in order to filter out data from unreliable sensors, and this information may or may not be transported over a network managed by a device like AICE.

Information Integration (Static)

The integration or fusion of information from multiple sources is a fundamental activity of command and control systems. This integration may be done automatically by data-fusion algorithms or done by humans examining incoming information. Static integration is done in batch, at one point in time. However, it can feed a sequential information process. For example, data from multiple sensors may be fused into an integrated picture of the situation, and a sequence of such pictures may be integrated to form an impression about enemy intent based on movement patterns.

Information Integration (Sequential, Dynamic)

Dynamic information integration is simply the fusion of information over time. It may be performed sequentially, if reports are received at fixed intervals, or almost continuously if reports come in at unpredictable intervals. Dynamic integration is triggered when information is received after filtering or static integration, and it in turn triggers transformation, storage, dissemination, and seeking. Information integration may lead to the seeking of information if, for example, the integration reveals that important information is missing.

Information Transformation

Information transformation is the “use” or “consumption” of information to make decisions or take actions. Transformation adds value to the information rather than simply transmitting it. The output of transformation is greater than the input, i.e., new information is produced. For example, a commander might view information on enemy location, make inferences about enemy intent, and issue commands based on those inferences. This process draws on the information in the commander’s head (experience and knowledge), but, from the point of view of an information-exchange network similar to the AICE, the commander has produced new information. There are information transfers both into and out of the transformation activity. Transformation may lead to information seeking (requests for information), dissemination of information (e.g., commands), or storage (perhaps for later dissemination).

Information Queuing and Storage

Not all information is transmitted or acted on immediately. Information may be stored for later use as a result of filtering or as a result of transformation. Sending information for storage is a type of information exchange (perhaps of less importance than other types of information exchange) that may or may not be accomplished via an AICE-like network. Information from storage may also be disseminated at a later time, and that also may or may not involve an AICE-like network.

Information Seeking

Searching for new information—information "pull"—is a fundamental activity of command and control. Seeking occurs when information available is less than information required to make a decision with an acceptable likelihood of being accurate. Associated with information seeking may be the need to adjust or instruct information-gathering devices/nodes. So, for example, an information-seeking exchange could be a command to a radar system to send a report on a certain area using certain search parameters. It could also be a request from HQ to an intelligence unit to send updated reports on enemy activity.

Information Dissemination

Information dissemination is the process of sending relevant information to other nodes or tasks. For example, an Air Tasking Order may be simultaneously sent to multiple locations. This activity, which almost certainly involves the AICE network could be simple (where few Source/Destination communication links cross between tasks) or more complex (where multiple Source/Destination communication links cross between tasks; See Figure 3).

We recognize that information usage activities reflect tactical and operational perspectives appropriate to the organizational level. It seems likely that there will be at least one source/destination link that goes across tasks, as shown at the top of Figure 3, but it seems more likely that there will be many source/destination links that go across tasks, as shown at the bottom. A general example and a specific example in the form of a Deep Attack Conceptual Case Study are provided in subsequent sections.

7. Construction of a Task Template Library

The performance of a task typically requires many different types of information exchange, each with associated policy elements. This raises the question of how best to define these exchanges in order to build a task template library and database.

We suggest that the information usage and management activities described above provide a natural structure for eliciting the information that is needed to populate task templates with mission-specific data. Specifically, we will use information activities to guide the development of questions that the SAGE will use to elicit the mission data required to construct an information policy. For example, to understand Information Seeking activities, the SAGE must address such questions as "What information is sought concerning this task?" "What is the priority of the required information?" and "Under what conditions is information sought in this task?" To understand Transformation activity, the SAGE must answer such questions as "What decisions are made in this task?" "What heuristics or algorithms are used?" and "At what point is the information sufficient to perform transformation?" These questions will be assembled in a table such that each user will get only the questions that s/he requires. The organization of the template will be standardized to maximize usability.

Table 1 shows the elements of a task template table. A richer set of representative questions is presented in Table 2. How might these questions be used? The SAGE would query the commander or staff to assist in implementing an operational plan (OPLAN) using a standardized task list. It would then present relevant questions and default answers or mission-specific answers, if available, for the mission tasks. The commander's staff would review and refine this material. Table 2 shows a notional template and illustrates the type of questions to be asked. (It is not intended as an interface design, however.)

Table 1. Elements of a Task Template Table.

Activity	Example Questions/Answers	Information Exchange		Typical Information Content	Relative Importance for task	Policy Elements for task			
		Source	Destination			S	D	C	I
A	*Representative questions* **B**								
	C	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**

The template for each task is decomposed into the seven information usage activities (i.e., seek, filter, integrate (static), integrate (dynamic), transform, store, and disseminate) in the column on the left (A). Within each activity, we list a broad sample of the questions that might be asked (B). The answers to these questions will provide the information exchange requirements to complete that activity in support of the specific task. (Only a sample of questions is provided in this example.) These questions may be asked at all or some of the organizational levels, but would be customized to the specific operational echelon that is completing the template. The questions would be individually presented (C) to elicit anticipated information sources and destinations. The source (D) and destination (E) of the information would be specified. Each information exchange would further indicate typical information content (F) and an assessment of importance of the information exchange (G) relative to completing that information usage activity in support of the specified task. These constitute the policy elements discussed earlier. Where an information element has utility for more than one operational unit, the source (H) of the information element for each operational unit (I) is specified (using a numeric code, in the case examples that follow). This supports increasing focus and granularity at sub-echelons and provides for identification and assessment of triggers based on changes in mission and importance cycles. Information contents (J) and the importance of the information (K) to each destination unit are also specified. Initial values are provided for these Policy Elements by Subject Matter Experts (SMEs), but the values can be adjusted if the situation warrants.

A more detailed template is provided in the following Conceptual Case Study section. As the SAGE begins to construct information policies, it would elicit more detailed data from

Table 2. Building Task Templates: Examples of Questions Generated from Information Usage and Management Activities for Task X

Task X									
Activity	Example Questions/Answers	Information Exchange		Typical Information Content	Relative Importance for task	Policy Elements for task			
		Source	Destination			S	D	C	I
Seek	What information is sought concerning this task? What is the priority of information requirements? Under what conditions is information sought in this task? How (at what points in time, in response to what events) does this task involve asking questions or getting more information? What supporting information is required? Are there multiple requirements for this information between tasks?								
	Information sought for Task X	from whom	to whom	Typical content	How important is this information for Task X?				
Filter	How is this task and its elements distributed throughout the organization? Is all of the information that comes in useful for this task? How is useful information identified? What do you need to know to decide if information is useful? Who will require this information? Are there criteria for sufficient information to allow decisionmaking? What are the priorities associated with the information for all intended users? Are there time latencies that will impact the value of the information?								
	What information could be used to filter what's important from what's not?	from whom	to whom	Typical content	How important is this filter for Task X?				
Integrate (static)	How is this task related to other tasks that might require all or some of this information? What are the multiple sources of information for this task? Is all information needed for decision making received simultaneously? Is the information a result of raw or combined data? How is the data combined? What is done with the information after it is combined? What length of time can be considered static, e.g., seconds, minutes? Is there a means to assess validity of the information? Is there a prioritization to the information? How are conflicts between information resolved, e.g., multiple sensor inputs?								
	Where might you gather information from multiple sources that must be fused?	from whom	to whom	Typical content	How important is this information for Task X?				
Integrate (dynamic)	Is information needed for decision making received over time (rather than simultaneously)? How frequently is new information received? What is done with the new information? How is this task related to other tasks that might require all or some of this information? Is there criteria for sufficient information to allow decisionmaking? What are the priorities associated with the information for all intended users? Is the information a result of raw or combined data? How is the data combined? What is done with the information after it is combined? Is there a means to assess validity of the information? Is there a prioritization to the information? How are conflicts between information resolved, e.g., multiple sensor inputs?								
	Where might you gather information that changes/develops over time?	from whom	to whom	Typical content	How important is this information for Task X?				
Transform	What decisions are made in this task? What information is used to make them? What algorithms are used? What knowledge sources are tapped? Who is informed? How are outputs of this task related to inputs to other tasks? Is there an iterative cycle for information development within this task? At what point is information developed in this task sufficient to make required decisions? How are information elements prioritized?								
	What decisions are made in Task X?	from whom	to whom	Typical content	How important is this transformation for Task X?				
Store	Does this task involve storing data that are not passed on immediately? How is this data aggregated to develop required information? How are some information elements retained as data for aggregation as well as processed for support to other tasks? Where are the data and information elements stored? Under what conditions are the data and information elements released from storage? Is some information retained as well as processed for dissemination simultaneously? Are storage limitations identified, e.g., time, type, size? What are the triggers to pull data from storage?								
	What information might be received during Task X that should be stored for later?	from whom	to whom	Typical content	How important is this filter for Task X?				
Dissemin-ate	Is information from this task disseminated? What messages/information types are sent as a result of this task? To whom are messages information sent? How is this task related to other tasks? Does this information flow vertically, horizontally, both? Is dissemination of this information time sensitive? How does the priority of this information vary between elements of the organization?								
	What information has to be passed on to others at the end of Task X?	from whom	to whom	Typical content	How important is this filter for Task X?				

subordinate echelons. Two characteristics of this interaction are important from a human engineering standpoint. First, the questions will be formulated in terms that are meaningful to users at each operational level. Second, only those questions necessary to “fill in gaps” will be presented to the user at each echelon.

As policy elements are built up for tasks between missions over time, we anticipate considerable commonality among tasks in the template library, allowing the SAGE and users (depending on level of automation), to cut and paste specific elements, with some modification, between similar tasks. For example, the policy elements associated with information integration in one task may be very similar to those for information integration in another task.

The task templates would be developed working with SMEs. Additional existing planning tools, doctrinal publications, tactical publications, field manuals, and other documentation would be reviewed and assessed for relevance and appropriate materials to develop task templates extracted, e.g., existing task matrices, operational/mission diagrams, organizational charts.

One interesting characteristic of experts in many fields [Chi, *et al*., 1981; Pennington, 1987] is reliance on multiple representations of a problem and rapid shifts between those representations. We propose that this system provide a variety of representations. We have mentioned the textual representation that includes questions and answers. In addition, users may benefit from diagrams of task flow such as that shown in Figure 5; diagrams of information flow between tasks; and diagrams of information flow between operational units. These representations would support both review of task and information flow, as well as revision.

8. A Conceptual Case Study Example: JSTARS Deep Strike Targeting Scenario[3]

To illustrate the concept of use of the SAGE and associated task templates, we provide a very limited conceptual scenario below. Templates for two representative tasks (from the task flow diagram in Figure 5) are provided. The first task relates to preplanning and was selected to demonstrate a query process relevant to a moderately complex information exchange environment with information resources that extend from the tactical to strategic level. The second task, monitoring for targets, represents a very limited information exchange environment in order to demonstrate a more focused query process. These task templates represent an aggregation of questions that would be disseminated throughout the organization based on the need to develop increasing levels of detail.

Following is a brief background of the scenario as well as a task sequence.

Scenario Background:

A peace enforcement operation in northern Africa has been on-going for a week. The conflict represents an escalation from a preceding month-long peacekeeping operation. Country X and

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[3] Joint Stars Deep Strike Targeting Scenario and task flow diagram courtesy of Honeywell

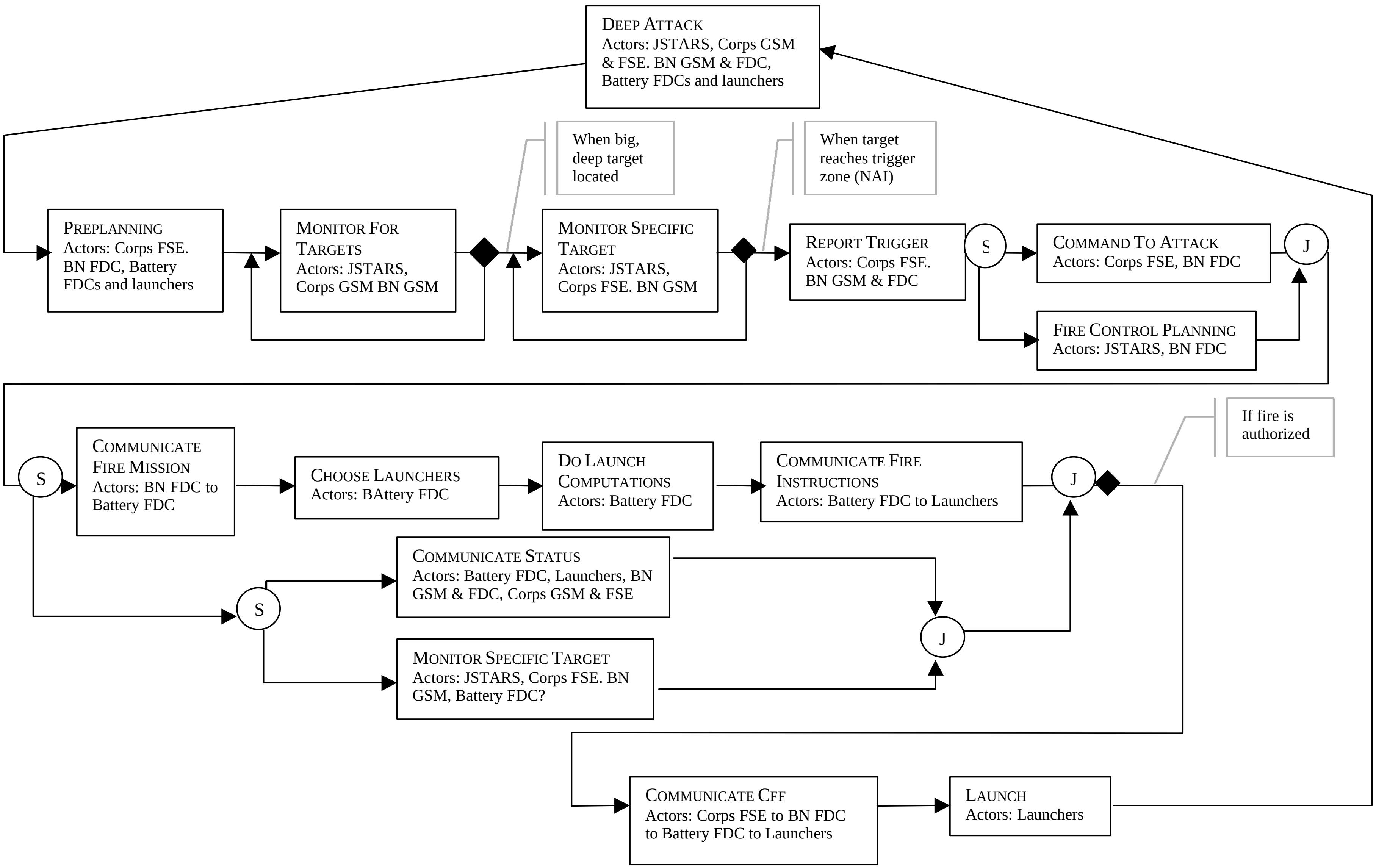

Figure 5: Task Decomposition of Deep Strike Scenario

Country Y have been engaged in a border dispute for several years over recently discovered energy reserves. The dispute has turned violent, resulting in multiple border clashes between ground units patrolling in the disputed area. These clashes have escalated in intensity and have the potential to destabilize the region if a war should result. The US, acting with UN authority, has moved to intervene to maintain the peace using elements of an Army Corps previously stationed in Country Y. A joint task force, TANGO, has been established and assigned the mission to prevent escalation of the conflict.

US ground forces are still in the process of building up. Initial US ground forces in place consist of Corps Headquarters, one mechanized division and two artillery battalions (with associated firing batteries) previously stationed in nation Y as well as USAF Joint Surveillance, Targeting and Reconnaissance System (JSTARS)[4] assets based in country Z, 500 miles away. Currently, the host nation, Y, has not authorized use of air facilities or positioning of naval assets in national waters other than for direct support of the buildup of the US ground forces. Intelligence, indications and warnings show that Country X intends to mass forces including two armored and mechanized divisions along its border with County Y in preparation for an invasion to seize the disputed territory. The disputed area is mountainous and consists of heavily covered transit routes. Detection of movements of ground units is anticipated to be achievable in limited areas and at limited intervals due to the terrain and adverse environmental conditions.

US forces have been positioned to detect and counter movements of hostile forces into the disputed area resulting in multiple Named and Targeted Areas of Interest (NAI/TAI). However, US forces have not been allowed to enter the disputed area, which is located within the recognized borders of Country Y. The NAI and TAI have variable and varying expectations of detection windows for detection and engagement of moving forces based on changes in environmental conditions and were established to reflect likely buildup and border crossing areas. Surveillance assets to cover the disputed area include intermittent use of national satellite assets and the JSTARS. However, due to other higher priority contingencies, use of national assets is expected to be minimal. Country X has been warned not to cross its border into the disputed area within Country Y. In order to counter movement of hostile forces into the disputed area, coordinated deep strikes between the Army ground units and the JSTARS will be required.

The JSTARS platform flies in an orbit at a safe standoff distance from the battle and collects and processes radar imagery in support of USAF, multi-service, and joint operations. For Air Force missions, the imagery is analyzed and targets are developed by analysts on board the E-8A. For Army targeting and intelligence missions, the imagery is downlinked to ground processing stations located with various Army command posts on the ground. In this scenario, the JSTARS is assumed to have an on-station time of approximately 8 hours and a transit to/from the patrol area of one hour each way. Tanker assets are not available. Continuous JSTARS support is assumed with a turnover between aircraft entering/leaving station. Limited/intermittent use of unmanned aerial

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[4] JSTARS employs a scanning radar for detection of moving targets on the ground, and is carried on a U.S. Air Force E-8A aircraft platform.

vehicles and intelligence reports from within the disputed area are available. In this limited scenario, Deep Attack on moving convoys by US Army forces is supported by JSTARS through an interface with the Corps Support Weapon System (CSWS). This requires extensive communication between the JSTARS E-8A, the Army Corps G2 (Intelligence), the JSTARS Ground Station (GSM), the CSWS Fire Direction Centers (FDCs), and the CSWS Battery itself (i.e., "the shooter"). This JSTARS Targeting Scenario can be broken down into 14 tasks (see Figure 5): preplanning, monitor for targets, monitor specific target, report trigger, command to attack, fire control planning, communicate status, monitor specific target (2), communicate fire mission, choose launchers, do launch computations, communicate fire instructions, communicate Calls For Fire, and launch. We will use two of these tasks, Preplanning and Monitor for Targets, to provide examples for development of the task template.

Task Descriptions:

Task 1: Preplanning. Preplanning is an extensive effort that includes all aspects of preparation for deploying forces and conduct of operations in a specified operational environment. For purposes of this scenario, the preplanning of interest is focused on stopping the movement of an armored column into the disputed area via a coordinated deep strike/attack. To demonstrate how task importance varies across operational echelons, preplanning can be looked at from the commander's broad operational perspective of what are the implications of the convoy's movements with respect to accomplishing his/her mission to the artillery battery's perspective of where is the target and what it should shoot it with. In this case, information such as location of the target would have different importance relative to each echelon. The commander would take into account a variety of concerns such as enemy intent, political implications of collateral damage, potential for escalation, best time/place to target, etc. The artillery battery is much more focused on target type (hard/soft), target disposition (concentrated or distributed), available munitions/weapons, and expected location at time of fire. Specific queries would be limited to those questions, and phrasings of those questions, necessary to elicit the information at each echelon to develop the necessary inputs to implement an appropriate information policy.

Table 3 provides an example of a task matrix that would provide the elements from which a coherent, aggregated set of information policies could be developed for the Preplanning Task. The table specifies questions to be asked for each type of information usage activity in developing the task template, and gives examples of the sources, destinations, contents, and importance of the information exchanges that were identified in response to those questions. Note that Sources and Destinations are specified using a numerical code defined at the bottom of Table 3, and that importance is rated on a scale from 0 (not at all important) to 1(very important).

Extensive preplanning and control is required in order to conduct Deep Attack on moving targets, including terrain analysis during operational/mission planning. In this scenario, the Fire Support Element (FSE) at Corps identifies the likely enemy avenues of travel based on intelligence inputs and reconnaissance. Along each route, they identify a series

Table 3. Task Template for Preplanning Task

Task 1: Preplanning

Activity	Example Questions/Answers	Information Exchange: Source	Information Exchange: Destination	Typical Information Content	Relative Importance for task	Policy Elements for task: S[1]	D[1]	C	I[2]
Seek	*Representative questions* **What information might be sought concerning this task?** What is/are likely points of detection? What is/are expected contents of convoy? What is/are Rules of Engagement (ROE)? What is/are mission priorities? What is/are threat order of battle? What is/are resources to engage? What is/are priorities of activities underway? What information resources are available? What is/are geographic area characteristics? What is/are current/anticipated weather conditions? What is/are terrain with respect to enemy movement? What is/are weapons limitations? What is potential for collateral damage? What is target composition (number of trucks/tanks/APCs, spacing)? What is/are deconfliction issues? What is/are coordination requirements with other friendly units? What is/are level of kill required? What is/are enemy ability to detect threats? What is/are known disposition of enemy forces? What is/are known disposition of friendly forces? What is/are known disposition of neutral forces? What is/are enemy intent?								
	What is/are likely points of detection?[3]	J5 or other planners, intel, operations people (who get spot reports), UAV controllers, tasking plan for the sensor (planning cell)	all command elements: jstars, corps, battalion, battery	geographic coordinates, times	Very Important (across the board)	3 8	4 5 6 7	geographic coordinates, times	5
	What is/are expected contents of convoy?	intel	all command elements: jstars, corps, battalion, battery	classification of contents (e.g., war materiel vs. consumer goods)	varies, depends on destination	1	4 5 6 7	classification of contents	1 1 2 4
	What is/are ROE?	command: CJTF	all command elements: jstars, corps, battalion, battery	criteria for engagement	Very Important (across the board)	2	4 5 6 7	criteria for engagement	5
Filter	*Representative questions* **What do you need to know to decide whether the information is useful?** What is the type of column (Armored? Soft?)? Composition of armored column? What is expected arrival time? What is expected speed of advance? What is expected target type composition? What is detectability given weather? What is detectability given sensor? What echelon needs what information when? What other tasks require/provide relevant information?								
	What is the type of column (armored? Infantry? Intermixed with neutrals?)	Battalion, Intel, Corps	all command elements: JSTARS, corps, battalion, battery	target type	varies, depends on destination	6 1 1 5	7 4 5 6	target type	5 3 4 2
	Composition of armored column	Battalion, Intel, Corps	all command elements: jstars, corps, battalion, battery	distribution, co-mingling (neutrals in the column?)	varies, depends on destination	6 1 1 5	7 4 5 6	distribution, co-mingling	5 4 4 4
Integrate (static)	*Representative questions* **Where might you gather information from multiple sources that must be fused?** What are the available sensors? What are the available intelligence and operational including reporting frequency?								
	What are the available sensors, including intell?	Battalion G3, JTF Operations J3, Corps G3, J-2, NSA, Corps G2, Battalion G2	battery, Corps, Battalion, JSTARS	JSTARS (or more generally a sensor name and its parameters) Intelligence estimates including intended destination and composition	varies, depends on destination, speed of advance and compositio n	6 3 5	7 5 6	sensor name and parameters, time?	1 4 2

Integrate (dynamic)	*Representative questions* **Where might you gather information that changes/develops over time?** What are the available sensors? What are the relevant intelligence sources? What is the frequency of reporting, e.g., intelligence and situation reports? Are non-military resources available, e.g., Commercial media, non-government agencies, other government agencies? What is the criteria for sufficiency of information to support decisionmaking? What is the perceived accuracy/reliabilitiy/priority of sensors?								
	What are available sensors to dynamically monitor the situation?	Battalion G3, JTF Operations J3, Corps G3, J-2, NSA, Corps G2, Battalion G2	battery, Corps, Battalion, JSTARS	Sensor names/parameters, routine reporting cycles/times, OPSITS/SITREPs,	varies, depends on destination, speed of advance and composition, assessed intent	6 3 5	4 5 6 7	sensor name and parameters, time?	4 4 3 1
Transform	*Representative questions* **What decisions are made on this task?** How can I use this information to conduct a terrain analysis? to determine the target list, NAI, and TAI? to determine available sensor platforms, times of availability, and airbase locations? To determine likely detection windows? To prioritize targets? To anticipate target times/schedule firing assets? To determine hostile intent? To determine intent of target movement/intended destination? Determine operational implications? Select types of munitions and numbers of rounds? Assess lethality requirements, e.g., mission kill vs. destruction?								
	Determine flight path for surveillance assets to orbit point considering distance and fuel	Airborne Surveillance Unit/Platform Commanders	Airborne Surveillance BN CMDR	information on distance and fuel	not very important		6	Distance; amount of fuel	2
	How can I use this information to conduct a terrain analysis?	G/J-2, G/J-3, FDC, FSE, JSTARS,	Corps, Battalion, Battery	Impassability, terrain types, chokepoints, covering points, hardened areas, type of cover	Varies: very important for planners and upper echelons, low importance to battery	4 5 6	5 6 7	NAI, TAI, chokepoints, estimates of munitions effectiveness, collateral damage potential?	4 3 2
	To determine intent of target movement/intended destination?	G/J-2, G/J-3, FDC, FSE, JSTARS	Corps, Battalion	Likely destination, speed of advance, composition, operational/tactical implications	Varies: very important at Corps and other operational level; moderate at Tactical/battalion level; minimal importance at battery level	4 5 6	5 6 6 7	Operational/tactical implications, path of intended movement	5 4 4 1
Store	*Representative questions* **What information might I get during preplanning that I should store for later?** What potential targets are in the area? Where are Launchers? Launcher ranges? Named Areas of Interest? Targeted Areas of Interest? Required type/number of munitions? Sensor availability? Munitions available/expended and type? Expected destination/progress points/times for column? Detection windows? Potential collateral damage? ROE?								
	Location of Launchers	Battery, battalion, corps	Battalion, corps, JSTARS	Geographic coordinates	Very important at battalion and Corps level; critical at battery level	7 6 5	6 5 4 3	Fields of fire, geographic location	5 4 4 4
Disseminate	*Representative questions* **What information has to be passed on to others at the end of preplanning?** What are the NAI and TAI? Expected target types, path of intended movement, composition? Requirements for surveillance and targeting? Weapons/munitions requirements? Prioritization of targets?								
	What is the NAI?	JTF, Corps, Battalion	JSTARS, Corps, Battalion, Battery	Geographic coordinates	Very important at all levels	3	4 5 6 7	Locations, anticipated targets/types	5

[1]codes for S (source) and D (destination): 1 =national intelligence; 2 = command (CJTF); 3 = JTF Operations; 4 = JSTARS; 5 = Corps-GSM; Corps-FSE; 6 = Battalion-GSM; Battalion-FDC; 7 = Battery; 8 = JTF Intelligence; 9 = National assets; 10 = non-military sources, e.g., NGOs/other agencies/Media

[2]Rating of importance on a scale of 1 (not at all important) to 5 (extremely important)

[3]a function of sensor, target, terrain, weather, dynamics of sensor tasking (e.g., is it in the area to observe targets)

of Named Areas of Interest and Targeted Areas of Interest. The Targeted Areas of Interest are preplanned fire zones placed in areas where convoys are expected to be detectable by JSTARS radar and that are conducive to attack by CSWS munitions. The Named Areas of Interest are simply coordination points preceding each Targeted Area of Interest. When a target enters one of these Named areas, final preparations for attack begin. This preparation includes predictions by the JSTARS GSM about estimated arrival time at the fire zone. In this scenario, the NAI are established on Country X's side of the border and are linked with TAIs in the disputed area. It is important to note that the tasks and supporting templates represented here are a very limited set of the specific activities that would be required in even a simple scenario. Some additional representative preplanning subtasks that would require task templates follow:

1. Perform Intelligence Preparation of the Battlefield
    a. Conduct Terrain Analysis
        i. Identify avenues of approach
        ii. Identify effects of current and predicted weather on trafficability
        iii. Identify areas mask/expose movement and attack intention
    b. Locate blue force positions and strengths
        i. Locate hostile garrison areas (from All-Source Intell)
        ii. Locate objectives (from All-source Intell)
        iii. Estimate hostile unit strength (from All-source Intell)
        iv. Estimate convoy size and mix for each unit/garrison
        v. Estimate rate of movement for each unit
        vi. Identify avenues of approach and adjusted movement rates
    c. Plan Sensor Flightpaths, Orbits, Periods of Activity Surveillance
        i. Determine available sensor platforms, times of availability, and airbase locations
        ii. Review incoming requests for sensor coverage and on-station time
        iii. For each request, examine flight requirements.
            1. Determine/plan orbit/flight path required to meet constraints of surveillance range and LOS terrain masking

2. Determine flight path to orbit point considering distance and fuel
3. Assess vulnerability to enemy air defense
4. Assess vulnerability to changing weather
5. Accept/modify/reject requests for coverage

2. Cue/Task Sensors

   a. Communicate proposed surveillance flights/missions to G2 and FSE
   b. Communicate mission taskings to airborne surveillance units

3. Execute Collection Assignments

   a. Develop All-Source Intelligence Analysis (Enemy Situation Estimate)
   b. This includes the same tasks as Intelligence preparation of the battlefield, only operating with dynamic information during the battle

4. Develop Deep Attack Plans

   a. Review Intell Prep of the Battlefield analysis
   b. Conduct terrain analysis
   c. Identify chokepoints, areas of delay and diversion due to terrain
   d. Identify sensor line of sight (LOS) masking at possible chokepoints
   e. Identify terrain constraints on weapon delivery (i.e. trajectories versus position of targets and terrain obstacles)
   f. Select areas along routes for targeting
   g. Review high priority targets for deep attack (from the commander)
   h. Prepare requests for sensor on-station time and area coverage
   i. Modify plan based on available surveillance support

Task 2: Monitor for targets. In this scenario, while monitoring the Corps Area of Interest for significant convoy movement (a task as indicated in Figure 5), the JSTARS GSM at the Corps G2 cell detects and identifies a large armored convoy moving toward the disputed area. This Corps GSM sends a message about this target ("hands it off") to the GSM at the CSWS Battalion FDC. Table 4 provides an aggregated task template (i.e., a task template that contains questions that would be asked of different users, as appropriate for each user's level and responsibility) reflecting the specific requirements to develop an information policy to support meeting task requirements. Again, the Corp.

Table 4. Task Template for Monitor for Targets Task

Task 2: Monitor for Targets

Activity	Example Questions/Answers	Information Exchange		Typical Information Content	Relative Importance for task	Policy Elements for task			
		Source	Destination			S[1]	D[1]	C	I[2]
Seek	*Representative questions* **What information might be sought concerning the task "monitor for targets"?** Is there movement near or into the NAI? How complicated is the tactical/operational picture? How many tracks are in the NAI? What tracks can be designated as targets? Is target a known hostile or assumed hostile? What is the targets' priority at Corps, Battalion, and Battery level? How fast is target moving? In what direction? What is the target's anticipated mobility and speed of advance into and through the NAI? What is target's intent? What is the reliability of my sensors? What sensors are available? What is the expected detection capability of my sensors? What are the counter-detection capabilities of the target? Are there additional non-hostile tracks in the vicinity? What intelligence and operational reports are available regarding estimated/known position of targets? What are the anticipated reporting frequencies? Has expected type/composition of target changed, e.g., split forces? What combination of information provides sufficient criteria to positively identify target? To designate the target? To make the attack decision? What are the ROE? What are the Critical Information Requirements as prioritized at Corps, Battalion, and Battery level? What are the CCIRs as prioritized at the JSTARS? What CCIRs relate to identify of this target and what assets are currently be employed to meet them? What additional/correlating sensors will be available in the next [pick timeframe of interest]? Given the terrain analysis, anticipated sensor availability/reliability, and anticipated target intent/destination; is there an optimum point to engage the target? What is the anticipated likelihood of losing track on the target?								
	What hostile, neutral, friendly units are in the area of interest?	Joint Stars	Corps GSM, Battalion GSM	information about the area	very important	4	5	graphics and RADAR imagery of the area	5
	What is target's intent?	Intel	Corps GSM	information about the target	very important	1	5	intelligence report	5
Filter	*Representative questions* **What do you need to know to decide whether the information is useful?** Are the forces near the NAI friendly, neutral, or hostile? Which organizational elements require information for contacts in specific NAI? What information is required by each organizational echelon regarding the contact, e.g., intent, path of movement, estimated position, composition, distribution? What is the priority of each NAI relative to organizational echelon? How old is the information? Is the information still required to support decisionmaking and at what echelon? Which sensors hold contact? What is their perceived reliability/viability at each echelon?								
	Are the forces near the NAI friendly or hostile?	Intel	Corps GSM	information about the forces	very important	1	5	Intelligence Report	5
Integrate (static)	*Representative questions* **What information might you gather from multiple sources that must be fused?** What is the current status, e.g., day/night/lighting, weather, visibility, of the area? What sensors have contact on tracks of interest? Are there positional differences between sensors? Are there significant potential time differences between detections? Are there disparities between sensors that result in conflicting reports?								
	What is the current status of the area?	Intel, Joint Stars	Corps GSM	information about the area	very important	1	5	intelligence report	5
						4	5	graphics and RADAR imagery of the area	5
Integrate (dynamic)	*Representative questions* **What information might you gather that changes/develops over time?** What units move into and out of the area? What is the current status, e.g., day/night/lighting, weather, visibility, of the area? What sensors have contact on tracks of interest? Are there positional differences between sensors? Are there significant potential time differences between detections? Are there disparities between sensors that result in conflicting reports? Is there stored information that is available to augment new information?								
	What units move into and out of the area?	Joint Stars	Corps GSM	information about the area	very important	4	5	Graphic/RADAR imagery of the area	5
Transform	*Representative questions* **What decisions are made on this task?** Does identified target match Deep Attack Criteria? What is target identity and intent? What means are best suited to counter the track? Is the track a threat? At what point should the target be engaged? Are there expected tracks/movements in a given timeframe? Has a friendly/neutral/hostile track exhibited characteristics sufficient to alter its designation? Have changes in mission/importance cycle resulted in specified priorities of potential targets?								
	Confirm target identity and intent.	Corps FSE, Corps G2	Corps G2, Corps FSE		LOW	5	5		2
Store	*Representative questions* **What information might I get while monitoring for targets that I should store for later?** What is target composition (number of trucks, spacing)? What is potential trafficability at specified times? What are anticipated detection windows in given areas? What are the characteristics that would allow classification of a contact?								
	How many trucks comprise the target?	Intel	Corps GSM	distribution of target	medium	1	5	distribution of target	3
Disseminate	*Representative questions* **What information has to be passed on to others at the end of monitoring for targets?** Is target a possible threat? At what level? Who is responsible to track/counter movements in specified NAI and TAI? What is criteria to report track to each echelon?								
	Report potential target	Corps GSM	Corps FSE, BN GSM	likelihood that target is threat	LOW	5	5 6		2

[1]codes for S (source) and D (destination) 4 = JSTARS; 5 = Corps-GSM; Corps-FSE; 6 = Battalion-GSM; Battalion-FDC; 7 = Battery

[2]Rating of importance on a scale of 1 (not at all important) to 5 (extremely important)

queries would be presented to the degree and in a form appropriate to specific users in the organization until a coherent information policy is developed. Inter-task dependencies would also be assessed.

Although preplanning and monitor for targets were the tasks chosen to illustrate the task templates for the JSTARS deep strike scenario, all of the tasks in the task flow diagram of Figure 5 would have separate task templates.

9. Summary

This paper has provided a concept for a tool to enable largely automated generation of information policies derived from defined mission tasks. This concept presents a web-based wizard (the SAGE) which functions to populate task templates that are used to derive information policies to facilitate accomplishment of the specified tasks. The SAGE elicits information from existing related task templates and databases to the extent feasible. Once information gaps are identified, the SAGE queries users at all appropriate operational echelons until a comprehensive and coherent set of macro and micro-information policies are established. Additionally, the SAGE monitors for changes to information policies throughout the organization, assesses their implications for requirements to change information policies, and triggers prompts to change those policies to appropriate users. Results of the SAGE's activities are presented to the user in a user defined format ranging from detailed task templates to process flow charts or combinations thereof. Moreover, based on user-designated preferences, the SAGE may operate as a highly automated engine or as a manual process.

A case study representing the application of the task template concept with respect to defined information usage activities was also presented. This case study demonstrated the spectrum of perspectives at each organizational level that must be supported by the task templates and wizard. The specific form of the SAGE, i.e., the query environment, is envisioned to be tailorable to specific user preferences and will only require sufficient input to enable the SAGE to complete the task templates.

Several issues will need to be resolved with respect to how the SAGE will function with respect to changes in mission and importance cycles. Additional work will be required to establish an appropriate typology for the various information policy elements. Further, inter and intra task relationships will need to be explored along with a mechanism for the SAGE to accommodate them.

10. References

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