Research Report 1362

The Cognitive Bases of Intelligence Analysis

J. R. Thompson, R. Hopf-Weichel,
and R. E. Geiselman
Operating Systems Division of Logicon, Inc.

Battlefield Information Systems Technical Area
Systems Research Laboratory

US ARMY RESEARCH INSTITUTE
for the BEHAVIORAL and SOCIAL SCIENCES
5001 Eisenhower Avenue
Alexandria, Virginia 22333

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EDGAR M. JOHNSON
Technical Director

L. NEALE COSBY
Colonel, IN
Commander

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Operating Systems Division of Logicon, Inc.

Technical review by

Beverly G. Knapp
Judith Englert

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This report summarizes the background research that led to development of the "Strategic Intelligence Analysis Handbook" (ITAC Report ATC-PP-2660-161-83) which was also developed under this contract. The goal of the research was to develop a framework for understanding human processes in intelligence analysis to be used in the development or evaluation of training procedures, doctrine, and system requirements for automated support to analysts. In addition to the strategic handbook, the research findings have (Continued)

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been applied to the development of training materials for tactical intelligence analysts and are summarized in the Training Circular "An Introduction to Tactical Intelligence Analysis: Cognitive Preparation for the Battlefield." This report summarizes a descriptive model of the cognitive structures and processes involved in analysis. It then relates both general and specific cognitive skills to the performance of analytic tasks within the context of threat modeling. The report also addresses analyst training, performance evaluation, automated systems, and future research directions.

Research Report 1362

The Cognitive Bases of Intelligence Analysis

J. R. Thompson, R. Hopf-Weichel,
and R. E. Geiselman
Operating Systems Division of Logicon, Inc.

Harold Martinek, Contracting Officer's Representative

Submitted by
Franklin L. Moses, Chief
Battlefield Information Systems Technical Area

Approved as technically adequate
and submitted for publication by
Jerrold M. Levine, Director
Systems Research Laboratory

U.S. ARMY RESEARCH INSTITUTE FOR THE BEHAVIORAL AND SOCIAL SCIENCES
5001 Eisenhower Avenue, Alexandria, Virginia 22333

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Human Factors in Training
& Operational Effectiveness

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FOREWORD

Intelligence collection systems have proliferated over the past several years, increasing in complexity and in volume of output. However, there has been no corresponding improvement in the ability of intelligence personnel to analyze this flood of data. The US Army Intelligence and Security Command (INSCOM) studies and the US Army Research Institute for the Behavioral and Social Sciences (ARI) research indicate that improved support to and training of analysts are necessary to effectively utilize the increased collection capability and satisfy increasing demands for intelligence within current personnel constraints. INSCOM and ARI therefore initiated a joint research program to provide improved support to the intelligence analyst. During early discussions of the issues, it became clear that any procedural, training, organizational, or system changes to support analysis will be effective only if based upon a detailed understanding of the analysts' role, methods, and thought processes in intelligence production. The first need was to evaluate and describe the human analytic processes underlying intelligence analysis, synthesis, and production.

The US Army Intelligence and Threat Analysis Center (ITAC) and ARI have successfully applied the research on the cognitive bases of intelligence analysis to the development of a handbook for strategic analysts (ITAC Report ATC-PP-2660-83). Given the growing demands upon ITAC resources, it is vital that new ITAC analysts become full contributing members of the ITAC team in as short a time as possible. The handbook provides new analysts with valuable background about ITAC as a work environment and intelligence producing organization. Perhaps most importantly, the handbook also emphasizes the cognitive tasks of analysis and the development of skills that enhance one's ability to think logically and analytically.

This report summarizes the background research that led to the development of the ITAC Handbook. First it describes the general cognitive model of intelligence analysis. It then identifies cognitive skills required of successful analysts and relates those skills to the performance of analytic tasks within the context of threat modeling. Finally, important issues related to the application of the research are addressed. This report should be very useful for the development or evaluation of other training procedures or materials, analytic procedures, doctrine, and system requirements for automated support to analysts.

EDGAR M. JOHNSON
Technical Director, ARI and
Chief Psychologist, US Army

COL DAVID T. HOTTEL
Commander, US Army Intelligence and
Threat Analysis Center

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This research effort would not have been possible without the cooperation of a number of organizations. Appreciation is extended to the Intelligence and Security Command (INSCOM), the Intelligence and Threat Analysis Center (ITAC), Forces Command (FORSCOM), the U.S. Army Intelligence Center and School (USAICS), and the Joint Tactical Fusion Program Manager's Office. These organizations provided the access to the intelligence analysts and systems required to accomplish this research. The intelligence analysts are heartily thanked for their cooperation, insights, and interest in our work.

The implementation of the research findings in the development of the "Strategic Intelligence Analysis Handbook" was accomplished with the assistance and advice of a Project Advisory Group (PAG). The contribution of the individual PAG participants and the cooperation and support of the agencies represented by these individuals are greatly appreciated.

PAG Participant	Organization	
Alan Goldman	USAITAC	PAG Chair
Ruth Phelps	ARI	PAG Co-Chair
Sharon Mutter	ARI	
MAJ Tony Durso	USAICS LNO to INSCOM	
Judith Englert	ARI	
Sy Frenkel	DIA	
Barry Wickersham	DIA	
Bob Procelli	Logicon	
John R. Thompson	Logicon	
LTC Quinn	OACSI	
Robert V. Katter	Logicon	
Wyatt Woodsmall	ARRADCOM	
Magda S. Ortiz	ITAC	
James Garwood	ITAC	
Terry J. Keller	ITAC	
Rick Clinger	Defense Intel College	
Jerry Hopple	Defense Intel College	
Tom Murray	CIA	
Pat McGrady	DIA	
Ward Swain	National Defense University	
Otto P. Chaney	U.S. Army War College	
James Tate III	USAITAC	
Don Cummings	USAITAC	
R. Wooldridge	USAITAC	

THE COGNITIVE BASES OF INTELLIGENCE ANALYSIS

EXECUTIVE SUMMARY

Requirement:

To develop a general descriptive model of the cognitive processes of intelligence analysis and to discuss how specific cognitive skills support the performance of analytic tasks.

Procedure:

The research approach was to examine the role and activities of various analysts experienced in signal, imagery, and all-source intelligence processing and production. In addition to data collected through interviews and observation, the research literature in the area of cognitive psychology was reviewed. A descriptive model of the cognitive processes underlying intelligence analysis was developed based on the general principles derived from the literature review and the interviews with intelligence personnel.

Findings:

The examination of intelligence analysis identified environmental and individual variables as well as underlying cognitive processes which contribute to the quality of intelligence. A major finding was that intelligence analysis is an internal, concept-driven activity rather than an external, data-driven activity. A summary of the early findings is available in ARI Research Report 1237. The present report builds on the findings reported there and identifies common problems associated with human judgment and reasoning that have implications for the training and support requirements of analysts.

Utilization of Findings:

Recently the research findings have been applied to the development of a Training Circular titled "An Introduction to Tactical Intelligence Analysis: Cognitive Preparation for the Battlefield" and to the development of a "Strategic Intelligence Analysis Handbook" (ITAC Document ATC-PP-2660-161-83). Included in the training materials are an overview of the cognitive skills of analysis, a recommended systematic approach to performing analysis, and discussion of analytical procedures and aids to support analysis. The research findings have potential application to analyst performance evaluation and to the identification of future training and system support requirements.

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1. INTRODUCTION

1.1 Purpose

This document serves two major purposes: (1) To provide a summary of the IMTIA findings and (2) to identify training issues and research/information gaps in the cognitive literature relevant to intelligence analysis. The document is organized into nine chapters: Following the introduction, Chapters 2 through 5 emphasize theoretical aspects of the background material used to develop training materials; Chapters 6, 7, and 8 describe relevant issues in applying the theory to an understanding of the day-to-day activities of intelligence analysts; Chapter 9 discusses research and development issues and training implications derived from these issues and from the theoretical considerations of Chapters 2 through 5.

IMTIA, a research project for the "Investigation of Methodologies and Techniques for Intelligence Analysis," was sponsored jointly by INSCOM and ARI. IMTIA research culminated in the development of a generic model of the mental processes underlying intelligence analysis. The theoretical concepts that were identified and defined during the IMTIA research have served as the impetus for developing training materials for strategic and tactical analysts.

Prior to the IMTIA research, the mental processes of the intelligence analyst were often treated as if they were in a "black box", i.e., inaccessible to research. There was little discussion about, and even less training to improve, these mental processes. IMTIA represents a first step towards describing and analyzing the cognitive tasks performed by analysts within the context of the analytic production system. The IMTIA research resulted in the development of:

- An all-source production model.
- A cognitive model of the intelligence analyst.
- Implications of the model for training and evaluating performance.

The first eight chapters of this document focus on the following five areas of inquiry:

1. *The cognitive underpinnings of intelligence analysis.* Chapter 2 describes those cognitive structures and processes that are particularly meaningful for understanding analytic behavior, and hence, for developing training materials. Chapter 3 discusses the meaning and relevance of conceptual models and shared conceptual models, as well as the knowledge requirements underlying optimum analytic performance.

2. *Generic processes and associated mental tasks that pertain to all analytic performances.* Chapter 4 discusses the general mental skills required by analysts. The specific mental skills, as made evident in nine generic task segments that underlie all analytic tasks are described in Chapter 5. These task segments are mentally-oriented performances, that, when combined, operate to fulfill *any* intelligence requirement.

3. *The threat model concept.* The structure and processes incorporated within the threat model are described in Chapter 6. The threat model incorporates the analytic context, products, and the means for developing those products.

4. *Means for evaluating intelligence training and performance.* To evaluate analytic performance and training needs, the concept of "ideal" states (representing analyst, performance, and product) has been advanced.

   Evaluation is the process of comparing hypothetical ideal states with actual performances and products. The ideal product is arrived at by developing all aspects of the threat model that are relevant to the mission requirements. Chapter 7 describes the concept of an ideal product and how to achieve this ideal product by following the steps for developing the threat model.

5. *Automated data processing uses and potential as analytic tools.* Chapter 8 describes existing systems that support the analytic process.

The above areas of inquiry have served to identify ways to improve analytic performance and areas that can be enhanced through training.

Chapter 9 identifies training issues and research and information gaps in the cognitive and decision making literature relevant to intelligence analysis. Identifying these gaps can serve as a basis for research designed to advance our knowledge and understanding of the cognitive bases of intelligence analysis.

This document can also serve as background material for intelligence analysts interested in some of the theoretical concepts underlying cognitive behavior in intelligence analysis.

1.2 Summary of IMTIA Findings

A summary view of the analytical process and its context is shown in Figure 1-1.

The analyst is shown as central to the analytic process, and as interacting with, and impacting on, the intelligence production cycle (users, context, requirements, intelligence product), available resources, and work setting context.

In developing a model to represent the cognitive activities of the intelligence analyst, LOGICON combined the results of more than two hundred interviews of analysts on the job, with extant models of cognitive thinking and of problem-solving and decision-making behavior. The resultant model can be described as a goal-oriented, context-specific, cognitive model of intelligence analysis.

The general goal for any intelligence analyst is to *reduce the uncertainties* of the users of intelligence. Reducing uncertainties involves fulfilling the intelligence requirements which can be defined in terms of the *ideal product*.

One of the primary aspects of intelligence analysis research is the use of models to represent behavior, environment, and communication. The use of such models has several advantages:

- A model is a means for representing only those aspects of a concept or situation that are relevant to the research.
- A model provides a way to define a subset of a situation of interest.
- Models force one to identify underlying assumptions.
- Models can be used to predict behavior or situations, and hence, to anticipate potential problems in performances or situations.

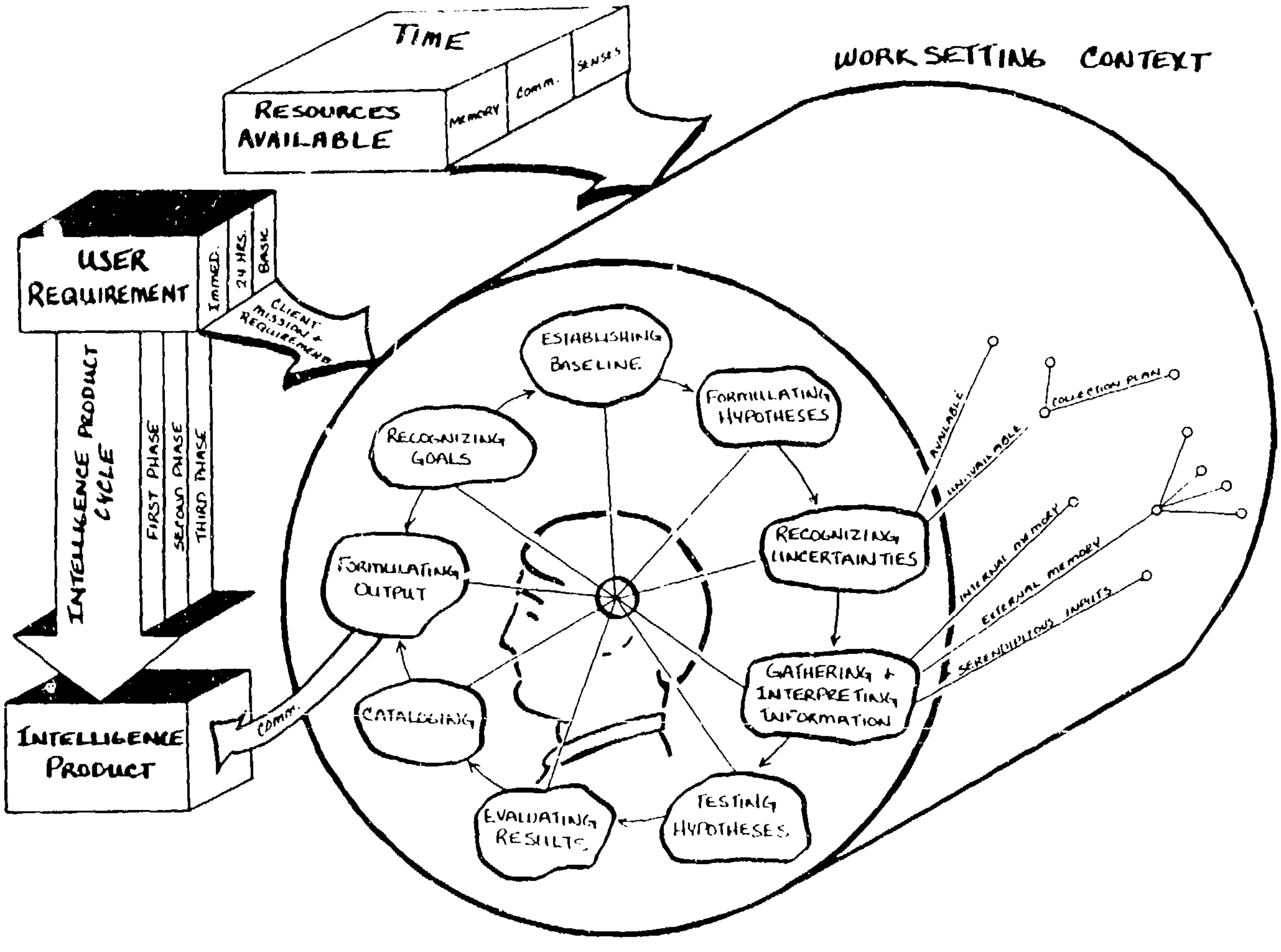

Figure 1-1: Model of the Analytic Process.

- Models can be used to identify areas of uncertainty with respect to some hypothesis. (e.g., in the world situation, for training research, etc.)

In the process of the IMTIA research, several different types of models were used. The major models were:

- The cognitive model of the intelligence analyst. This model describes the memory structure and processes of the cognitive system, emphasizing those functions that are relevant to intelligence analysis.
- Conceptual models and shared conceptual models. A conceptual model is the functional unit in memory that determines how humans perceive and understand their environment and how they communicate with each other. Shared conceptual models are knowledge areas shared by two or more individuals (e.g., language, mission requirements, etc.). No communication is possible without shared conceptual models.
- The cognitive framework of the intelligence analyst. This is an expanded version of the cognitive model. It sets the cognitive and conceptual models of the intelligence analyst in the larger framework of the environment in which the analyst works. This framework identifies the major aspects of the analyst's environment that impact on the analyst's thinking processes, such as the analyst's goals, mission requirements, user requirements, work setting variables, analytic tasks, and input information that is used in creating the analytic product.
- The production model. This model describes the intelligence production system as it interrelates with the analytic tasks and affects the operational mission.
- The threat model. This is a model of the geographic environment, and of the enemy and friendly situations within which the analytic product is developed. It represents the most important conceptual model shared by analysts and the users of intelligence.

These models are considered separately for practical purposes and for clarification. In reality, the phenomena underlying the models are all connected and the aspects represented by each model interact to produce a comprehensive view of the working analyst interacting with the analytic requirements.

In summary, the concepts evolved during the IMTIA studies and represented by these models can be used to:

- Evaluate analytical performance and intelligence products.
- Develop training materials that can compensate for shortfalls in performance and products.
- Improve communications effectiveness throughout the production cycle.
- Define better uses of automation.
- Devise means for skill maintenance and improved transfer of training.

The major findings and concepts that arose from the IMTIA study are summarized below:

- Intelligence analysis is a process whereby:

- Information is collected in response to stated needs and requirements.
- Analysts must deal with problems of sparse data and scarce resources.
- Raw information is transformed (processed and analyzed) so as to answer specific questions concerning a real or potential threat to national interests.
- The transformed information is combined into an intelligence product and communicated to a user.

- The research that led to the development of the threat model is represented by the generic cognitive model of the intelligence analyst. The model emphasizes the importance of goals as the impetus for behavior.
- Goals serve as the basis for determining "ideal states" for analysts, performance, and product. Ideal states can be defined, and serve as a basis for evaluating performance and products of intelligence analysis. The ideal product serves as a checklist against which to evaluate an actual intelligence product.
- If the ideal product is specified in sufficient detail for a particular context and user, the ideal product can also serve as a basis for determining collection requirements and allocating available resources.
- Behavior and performance are only meaningful when analyzed with respect to context (work setting variables and environment). While cognitive processes and cognitive skills are incorporated within the model and represent generic processes applicable to all types of analysts, specific applications of the model (e.g., to training, automation issues, skill maintenance, etc.) must be context-specific.
- There are internal and external contexts. Internal contexts are referred to as "conceptual models". Conceptual models and shared conceptual models are major concepts for identifying certain performance and communications issues. Conceptual models determine how well analytic tasks are performed.
- Analytic tasks are performed by variously combining nine generic task segments. These task segments represent the mental performances underlying intelligence analysis. The cognitive model is applicable across all types of intelligence disciplines.
- External contexts are described by the IMTIA production model and consist of geographical environments, work setting variables, other analysts, users, data sources, and so forth.
- The construct of major importance to an intelligence analyst is the *Threat Model*. The threat model combines internal and external contexts as defined above. It is a multi-dimensional representation of the battlefield environment, used for integrating informational elements, analyzing options, externalizing mental concepts, communicating with other analysts and users, and making predictions of future possibilities and potential events.
- The intelligence product itself, as well as changes in missions, users, requirements, and environment, serve to generate new collection requirements and new analytical questions.

2. COGNITIVE STRUCTURES AND PROCESSES

This chapter provides an overview model of the generic human information processing system as studied in cognitive psychology, with particular emphasis on features that relate to intelligence analysis. This model represents an organizational framework for discussing cognitive structures and p: .cesses, but does not depict the entire cognitive model with all of its complexities as presented throughout this report. The model consists of two components: static cognitive structures and dynamic processes that are brought to bear on information held in the system. These components are hypothetical in nature and do not at present have definite physiological correlates in the brain. In subsequent sections, the information-processing model is used to discuss several performance issues relevant to effective intelligence analysis.

2.1 A General Information-Processing Model

Models of human information processing are made up of two components: (1) hypothetical memory structures that retain information and (2) processes that operate on the information received from the environment and that direct the flow of information from one structure to another. The model presented in Figure 2-1 summarizes at a very general level selected aspects of cognitive functioning that are logically involved in intelligence analysis.

Depicted on the left side of the figure are the external inputs to the system (the external work setting context, including retrieval of old data from intelligence journals or other external memory devices). The right-hand section of the figure represents the unobservable processing of information within the analyst's mind leading to observable behavior. This processing is hypothesized to consist of the interaction of three types of memory: active memory (consciousness), episodic memory, and semantic/factual memory. The present discussion is not concerned with lower-order sensory processes.

Active memory contains the information that the analyst is consciously processing at the moment. Active memory is said to have a fixed capacity for holding and operating on information (Baddeley and Hitch, 1974) and this capacity is believed to vary somewhat from individual to individual. The greater the capacity, the greater the person's ability to aggregate and integrate separate elements of information into higher-order units. It is believed that individuals can learn "cognitive economy" or strategies for chunking information together so as to increase the total amount of information that can be held in active memory at one time, but the number of chunks that can be held at one time (the capacity of active memory) cannot be increased with training (Chase, 1978). The use of learned conceptual models of the world as information chunking devices (see Chapter 3) provides one method for circumventing the limited capacity of active memory. For example, a large amount of data concerning a certain configuration of enemy units and movement could be summarized simply as a doctrinal attack pattern. The use of automated memory aids and/or team memory provides an additional strategy for reducing the likelihood of information overload in active memory (see Sections 2.5.1 and 2.5.2). The more complex the operations being performed in active memory, the smaller the amount of information

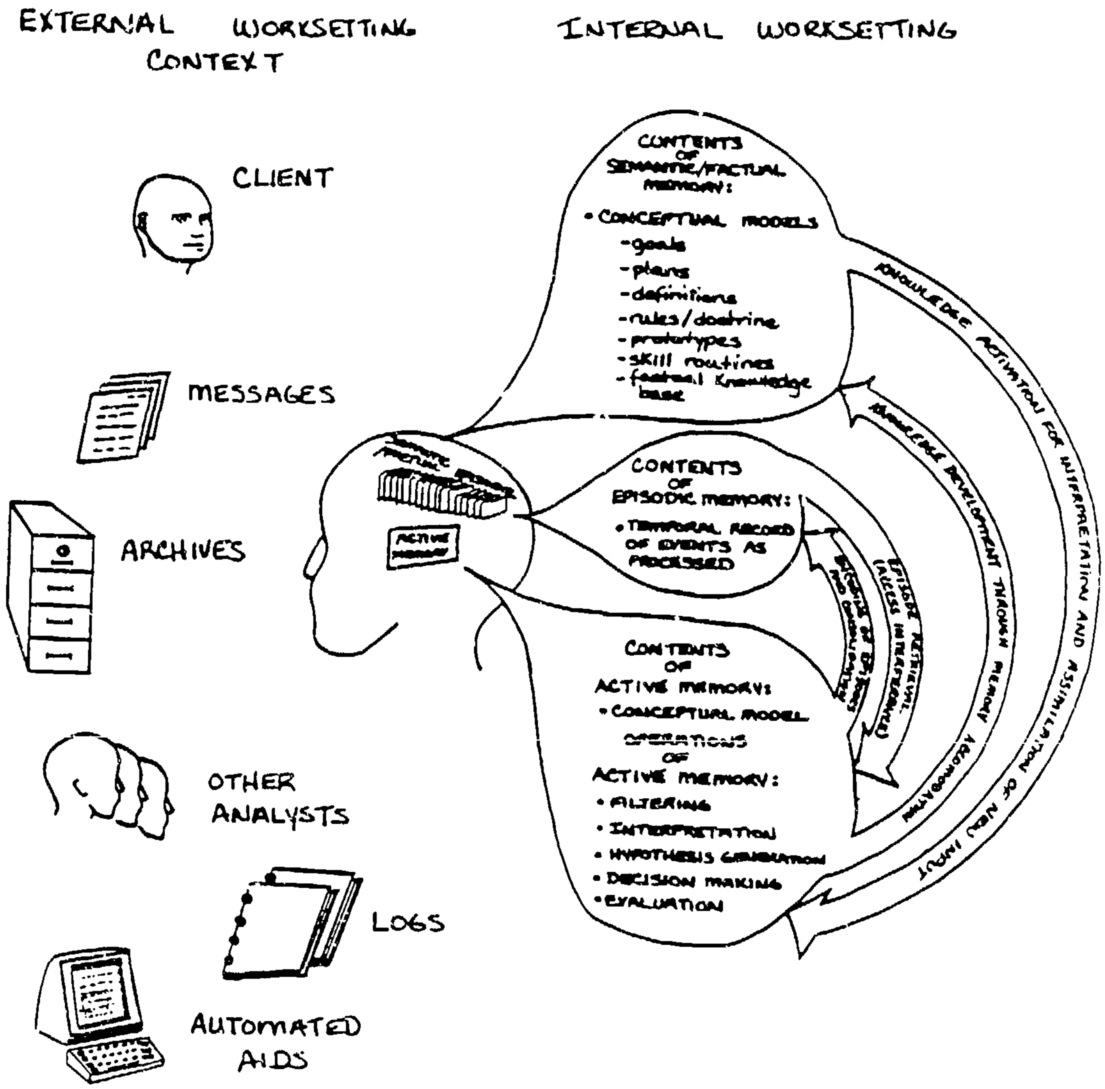

Figure 2-1: General Model of the Human Information-Processing System.

that can be operated on at that time (Geiselman and Bellezza, 1975). For example, rote journalizing of data would be less likely to interfere with the ongoing monitoring of incoming information than would hypothesis generation.

Episodic memory contains a record of the perceptions and thoughts (encoding) experienced by the analyst. The greater the frequency of processing and/or the amount of processing given to information, the greater the consolidation of that information in memory. The consolidation process is discussed in Section 2.2.2. The episodic record is ordered temporally and is believed to have no identifiable capacity limitations. Although some memory theorists speculate that no information is ever erased from episodic memory, all agree that some memories are more accessible than others. Memory accessibility varies from time to time and with the immediate retrieval context. Although recognition memory is typically higher than recall memory, manipulation of the context at the time of memory retrieval can produce situations where recall performance actually exceeds recognition performance (Flexser and Tulving, 1978). It is important for the intelligence analyst to recognize memory-retrieval shortfalls so that external memory aids are utilized effectively and memory inaccessibility or non-recognizability is not interpreted as an absence of the information in question. Problems of memory access relevant to intelligence analysis are discussed in Section 2.2.3.

Semantic and factual memory contains a knowledge base that is not temporally dated or linked to specific episodes (such as definitions of terms and doctrine) or to organizational/procedural structures (rules of logic, conceptual models, prototypes, goals, plans, biases, skill routines). Information structures held in semantic and factual memory provide the basis for interpreting the world. The development of "expert systems" is, in part, directed toward modeling and understanding the semantic/factual knowledge of individuals who show a high level of performance within a particular domain of interest. A major goal of the human information-processing system is to make irregular patterns of information regular. This goal is reflected in the interaction between semantic/factual memory and active memory as depicted in Figure 2-1. Assimilation refers to the modification and elaboration of new information to fit prior conceptions or hypotheses (i.e., interpretation of information through selection and generalization, see Section 2.2.1). Accomodation refers to the modification of the existing contents of memory (e.g., within a conceptual model) to accept new or inconsistent information. These two processes are the mechanisms through which knowledge is acquired. When assimilation is carried to an extreme, a bias toward confirming pre-conceived hypotheses is in evidence (as with a confirmation bias, see Section 2.4.4); whereas when accomodation is carried to an extreme, the analyst may disregard the probabilistic nature of intelligence data and exhibit a bias toward switching hypotheses upon receipt of minimally conflicting information. Both of these extreme tendencies are more likely to occur under conditions of stress.

The analyst can avoid the possible negative consequences of the extreme cases of assimilation and accomodation by utilizing an evaluation structure that allows weighting of evidence in both *past* and *future* episodes of the ongoing scenario. Over-assimilation can be avoided by retaining a structure for indicators and episodes of alternative hypotheses. Over-accomodation can be avoided by forcing an archival justification of new hypotheses to the equivalent level of established hypotheses.

2.2 Information Contents Modification Cycle

Cognition within the above information-processing system may be characterized as a set of interrelated processes that operate on the available information contents in memory and modify them.

Since information from the senses and in memory constitutes the raw material upon which intelligence analysis is based, information modification mechanisms have important implications for understanding and predicting the orientations and nature of analytic interpretations and estimates. The descriptive model of analytic behavior developed here builds on an understanding of basic cognitive processes and attempts to explain analysts' interpretation, storage, and recall of information. At a general level, the model describes the dynamic interplay between incoming information and previously stored information (i.e., internal memories). Processes that are central to this interplay encompass the memory modification cycle involving information filtering, memory consolidation, and memory access interference.

Associated with these mechanisms are several shortfalls in information processing tied to limitations of the human information processing system. These problems are presented and candidate safeguard... or solutions are offered. ı some cases, simple awareness of the problems may limit their occurrence.

2.2.1 *INFORMATION FILTERING*

The *information filtering* mechanism is composed of two complementary functions: selectivity and generalization.

The *selectivity mechanism* filters the raw information pattern and selects out those aspects that are significant. This is done by comparing the contents of the currently active conceptual model (see Chapter 3) with the raw information. If an adequate match is found that tags the raw input as significant, the input is assimilated into the analyst's data base as a member of an existing mental category.

This initial comparison often results in passively rejecting significant information in the raw input because it does not fit the mental category assigned to it. If the overall first impression of the input information pattern is a good match with the gross features of existing memory contents, disparities between the input pattern and the memory information pattern at more detailed levels are frequently not even noticed. Thus, actual disparities are ignored and the erroneously perceived information is assimilated into the existing conceptual model (see Figure 2-1). Selectivity reduces memory load for specific instances, but details that are ignored may later turn out to be significant.

Selectivity is biased by expectations. This bias is the result of a mechanism called *polarization filtering*. Polarization filtering is a variation of selectivity filtering, in which an expectation that has been established increases the accessibility of memory contents related to that expectation. This includes information for confirming or denying exp ctations, although in general, positive expectations are more prevalent, leading to the *confirmat' . bias* (see Section 2.4.4). When these expectations are related to formal analytic hypotheses, polarization filtering leads to accepting such hypotheses with insufficient evidence (Type 1 error). The polarization effect focuses attention on the features of the expectation, thus passively rejecting other potentially important information that happens to be irrelevant for confirming or denying the expectation.

The polarization effect can bring positive results when unfolding events correspond to expectations, and negative results when events are unrelated to confirming or denying expectations. Polarizing effects are stronger when an expectation is implicit (i.e., is unexamined or unquestioned in awareness). Therefore, explicit questioning of expectations and identification of underlying assumptions can reduce polarization. This is the reason that the IMTIA research has identified the need for intelligence analysts to develop their skills in "identifying assumptions" (see "Handbook for Strategic Intelligence Analysis").

In contrast to selectivity mechanisms, *generalization mechanisms* filter raw input information by determining the types and degrees of similarities required to recognize things as members of well-known categories. The confident use of acquired knowledge depends on being able to generalize from experience. Generalization is a fundamental process for organizing large numbers of unique instances into manageable form. Success in applying past experience (memory information) to the present depends on the validity of the generalizations employed. Given that generalization often ignores significant differences between specific instances, such differences should be recorded as appended information in the event that the generalizations should later prove invalid.

2.2.2 *MEMORY CONTENTS CONSOLIDATION*

Memory contents, including information recently passed through the filtering process and stored in episodic memory, are consolidated (i.e., made more accessible and vivid) as a joint function of the frequency of processing and the amount of attention used in the processing. Thus, more frequently encountered, important types of experiences upon which significant mental effort is expended become more vivid and immediately accessible in memory.

The increased accessibility and vividness of particular memory contents increases the likelihood that they will be used as filtering criteria for future, somewhat similar raw experiences. For this reason, the contents consolidation mechanism can have important implications for the accuracy of analytic interpretations and estimates. If the results of the consolidation mechanism match the realities of future events to be interpreted, the effects of consolidation are advantageous; if not, the effects are detrimental. Long term static conditions tend to increase the positive aspects of the consolidation process, while eras of rapid and significant change do not.

Consolidation can result in a phenomenon called the *caricature effect*, a type of distortion of the input information following mental rehearsal of an experience, rumination about an experience, or problem-solving behavior about an experience. These cognitive activities can increase the accessibility and the vividness of the particular memory contents related to that experience. Given no additional external information about a certain experience, continued rehearsal, rumination, and thought tend to emphasize and de-emphasize various aspects of the memory of that experience.

The result of emphasis and de-emphasis is to "normalize" usual or expected aspects of the memory and to exaggerate unusual or unexpected aspects, with usualness/unusualness being judged in relation to the rest of the overall memory structure. That is, the consistency of usualness between some of the contents of the particular memory and the balance of memory contents may be exaggerated beyond their original consistency, and the disagreement and inconsistency in other parts of that particular memory may also be exaggerated beyond their original condition.

Since the combined results of these processes tend to produce a memory that is a caricature of the original contents, the result is termed the caricature effect. This effect tends to feed on the elements of unusualness and surprise and to overemphasize these elements as compared to the more expected elements of the experience. If the novel elements of an experience are accurate components of a future similar event, the caricature effect may provide help in interpreting the future event. If not, the caricature effect can impede accurate interpretation, especially if the interpretation must be based on incomplete data.

The caricature effect is a special "no new information" version of the consolidation mechanism (the latter being based on repeated instances of a certain pattern of external experience). Since the caricature effect depends partly on the experience of initial surprise followed by unshared and unexamined rehearsal and rumination, the conditions for predicting and controlling the caricature effect are at present only partially understood. This effect might be minimized by reviewing the journalized record of the initial interpretation and perhaps by discussing the unusual aspects with other analysts.

2.2.3 *MEMORY ACCESS INTERFERENCE*

For memories to be useful to the analyst, the analyst must be able to access them. Accessing a memory of an earlier event occurs in one of two ways: recall or recognition.

- Recall consists of accessing the memory contents from an earlier experience when receiving a name or description of the situation within which that event was experienced. Recall consists of, for example, responding to the question "What kinds of vehicles were present in the imagery you viewed before lunch yesterday?"
- Recognition consists of accessing a memory for an earlier situation that matches currently presented specific information. Recognition consists of, for example, responding to the question "Is this frame of imagery the same as one that you viewed before lunch yesterday?"

Interference in accessing memory occurs for both recognition and recall. Memory retrieval is most efficient when the memories are discriminable. Memories for very similar experiences can interfere with one another during memory access from episodic memory, slowing access and making it less reliable and less accurate. Such interference can have strong effects on the memory information available for the filtering stage of the next cycle.

The two main interference effects are the *intervening similarities effect* and the *similarities saturation effect.*

For both recall and recognition, highly similar experiences that have intervened between the original experience and the current requirement for memory access tend to interfere with the accessibility of the original memory material; the *intervening similarities effect* creates interference with memory access for both recall and recognition. Thus, an analyst processing many messages of very similar contents from the same domain, under constant conditions, and over an extended period of time, is unlikely to be able to recall the specific messages processed during a certain period of time. Also, the analyst may not be able to recognize a specific message presented for re-examination as having ever been processed.

External memory aids should be used when intervening similarities interference can be anticipated, and when it must be circumvented. The use of external memory aids is discussed in Section 2.5.1. When interference cannot be anticipated, and is recognized only after the events have occurred, the analyst should try to mentally reinstate the context surrounding the event in question, drawing upon any unusual details that might make the memories discriminable.

The *similarities saturation effect* occurs following concentrated repetitions of highly similar experiences that saturate related areas of memory with many highly similar memory contents. This increases the difficulty of comparing across, and discriminating between, many similar memories, and causes reduced speed and accuracy in the processing of each new related experience. It also interferes with rapid and discriminable storage of the similar new experiences in memory. The similarities saturation effect can be lessened by providing the individual a chance to refocus attention on *different* memory contents, if possible, thus allowing the interfering memories to become less vivid and less immediately accessible. Following recovery from saturation, the capacity for new discriminations in that area of memory is restored.

The intervening similarities and similarities saturation forms of interference with memory performance are predictable cognitive mechanisms of information processing. They operate to weaken and diffuse the experiential information available from episodic memory by affecting the speed, reliability, and accuracy of access to memory contents. Such weakening and diffusion can change the pattern of the memory contents that will be used as filtering criteria for the next cycle of experience and memory modification.

In summary, there are three potentially predictable and controllable cognitive mechanisms that operate in a cycle to modify information contents available from memory. Since memory contents provide a large portion of the information used in making many intelligence analysis interpretations and estimates, the information contents modification cycle is an important concept for suggesting ways to improve intelligence analysis.

Within this cycle, information is filtered, consolidated, and otherwise modified. Selective filtering may operate to ignore (filter out) aspects of the input information that diverge from stored information. Polarization, stemming from established expectations, may increase the chance of processing information that would otherwise have been filtered, but it may also lead to filtering of other information not directly related to confirmation or denial of the expectancy. Generalization is an important mechanism that operates during the filtering process to aggregate large amounts of data into manageable form.

Input information that has passed through the filtering process is consolidated with pre-existing information contents. The consolidation process increases access to frequently used information, but it may also lead to various distortions of the information. Accessibility to memory contents is also determined by the relationships of various kinds of information in storage. For example, input information that is highly similar to stored information can create confusion and interfere with recall or recognition.

2.2.4 *AWARENESS OF MEMORY FUNCTION*

Often we are not aware that we use information that comes from memory. A simple illustration of this phenomenon can be seen in the contributions of memory to the task of identifying a military vehicle masked by a tree. Visible parts of the vehicle provide the cues for matching and decoding memory contents and reconstructing the visually missing parts of the vehicle. As the fill-in is accomplished, the image of the tree is effectively dimmed or the event erased from consideration. At this point the tree is down-graded or eliminated from awareness, and a "camouflaged tank retriever" is confidently reported. The process of using information from memory for fill-in is usually dismissed or not even noticed. The same sequence of data occlusion, fill-in, and downgrading of irrelevant information occurs continuously for conceptually more complex and subtle forms of experiences associated with analysis. Fill-in is a useful process because it allows for interpretation and prediction when only partial information is available, but it can also lead to premature interpretations of the data. Data occlusion and downgrading of information are also useful and indispensible information processing mechanisms, used for organizing and filtering data; they save time but they can also lead to inadvertent oversights of potentially important information. Intelligence analysts must be aware of these limits of the cognitive mechanism.

2.3 Positive and Negative Aspects of the Processing System

The structural and processing characteristics just described have both positive and negative aspects associated with it. The constraints on the human information processing system have the following positive results:

- Constraints make it possible to organize multitudes of environmental stimuli into meaningful categories.
- Without categorization, meaning could not be assigned to the various perceptual inputs.
- Perceptual inputs could not be assigned relevance values.
- Similarities between stimuli that lead to the assignment of items to categories would not be recognized.
- No reference points would be available to make judgments or predictions.
- Patterns would not be recognized as meaningful.
- Probability assignments of future possibilities would be impossible.

In other words, characteristics such as filtering, assimilation, and consolidation are adaptive processes. They can be thought of as rules imposed by the cognitive system that are responsible for organizing environmental stimuli into meaningful information and make it possible for humans to deal with new and with old information. At the same time they also tend to distort the true picture of the world and in that capacity, they are at the basis of cognitive biases. Cognitive biases have received a great deal of attention in the information processing literature and are particularly relevant to intelligence analysts. who must make inferences based on uncertain and sparse data. While the rules of the cognitive system tend to work well in everyday situations, intelligence analysts deal with situations that are much more structured and that require more discipline. In such situations, the effects of cognitive biases tend to be more pronounced and consequential. These effects can be partially circumvented through awareness.

In the following paragraphs, the major recognized biases are briefly described.

2.4 Cognitive Biases

The term bias refers to a subjective point of view. Typically, the term is used to indicate preconceived (and generally false) notions, attitudes, or judgments about something or someone. Biases are the result of being associated with specific environments, or they are the result of specific characteristics associated with the human information processing system. Biases can be categorized as follows:

- Cultural and Personal.
- Organizational.
- Cognitive.

Cultural biases are constraints on ones thinking, acquired during maturation from widely held beliefs, practices, or cognitive styles that characterize one's specific social environment. Personal biases are constraints that arise from specific past experiences of the individual. Organizational biases are constraints on cognitive flexibility imposed by local information, goals, mores, and traditions, that have evolved within the specific organization in which the individual serves. In many instances, cultural, personal, and organizational biases are in fact identical to the underlying assumptions that were discussed in the previous section.

Cognitive biases differ from the above in that they are to a large extent inherent characteristics of the way humans think, both in the way they recall information from memory and in the way they process (perceive and understand) information from their environment.

All humans are influenced by biases. The important issue, for analysts, is to recognize the types of biases that exist and be aware of the potential influences that these biases may have on intelligence analysis.

While cultural, personal, and organizational biases tend to distort one's view of the world, cognitive biases are not necessarily detrimental to one's thinking. In the absence of information, a preconceived idea about something can at least give the analyst a starting point for thinking about a situation. However, it is critical for the analyst to realize that the source of the idea is internal, and that the uncertainty level associated with it is quite high.

In general, cognitive biases tend to distort what is remembered, how it is remembered, as well as how information is evaluated. Several of the more common cognitive biases are discussed below.

2.4.1 SELECTIVITY BIAS

Information is selectively recalled as a function of how vivid, concrete, and personal it is. Vivid information has a greater impact on thinking than pallid, abstract information that may objectively have greater value as evidence. Information that is personally perceived is also likely to be better remembered than information received secondhand. Initial impressions and items that are first in a series also tend to be more vivid, and hence, better remembered.

Intelligence analysts generally work with secondhand information. On occasions when the analyst directly perceives information, such as during foreign travel or through direct communication with a national from a particular country, these events and information will become especially noteworthy. Such vivid experiences are often a source of new insights, but they can also be a cause of self-deception, and hence, they can bias your interpretation of a given situation. In the instance of foreign travel, the visitor typically will become familiar with only a small sample of people representing a narrow segment of the total society. Incomplete and distorted perceptions are a common result of the selectivity bias.

2.4.2 AVAILABILITY BIAS

The ability to recall instances of an event is influenced by how recently an event occurred, by personal involvement, by how important it seemed at the time, and by vivid details. All of these factors are unrelated to the true probability of an event. These factors do, however, influence our judgment by making recall of such events more easily "available" from our memory.

When making judgments about the likelihood or frequency of certain events, the availability rule of thumb is used. According to this rule, the probability of some event is judged by the ease of imagining relevant instances of that event or the number of such events that we can easily remember. The availability rule often works quite well, but it can be misleading when the recalled vividness of an event is unrelated to its probability.

Using the availability rule is a time saver, but the intelligence analyst must be aware of such shortcuts and recognize the strengths and weaknesses of their use.

2.4.3 ABSENCE OF EVIDENCE BIAS

A principal characteristic of intelligence analysis is that key information is generally lacking. Analytical problems are selected on the basis of their importance and the perceived needs of the users, without much regard for availability of information. Analysts must do the best they can with limited information, but they must also anticipate the gaps and somehow take into account the fact that relevant information is known to be missing. Missing data are a normal characteristic of intelligence problems. Research has shown the difficulty that even experts have in recognizing and incorporating missing data into judgments of abstract problems.

The notion "out of sight, out of mind" should not be a description of the impact of gaps in information. The analyst needs to be able to explicitly identify those relevant variables on which information is lacking, consider alternative hypotheses concerning the true status of those variables, then modify their judgment (and especially their level of certainty) accordingly. It is also relevant to consider whether a lack of information on such variables is normal, or whether the absence of information is itself an indicator of unusual activity or inactivity.

2.4.4 CONFIRMATION BIAS

The confirmation bias is the result of the tendency to perceive events in such a way as to confirm existing beliefs. It can occur in one of two ways. The first occurs because of a tendency to only *perceive* events that fit within existing conceptual models. The second way is *distorting* the meaning of what is seen, so that it fits preconceived ideas.

The confirmation bias is very pervasive; it is a result of a need to understand the environment in terms of what is already know. This need leads to perceiving what is expected to be perceived.

This is important to remember during the process of generating hypotheses about a situation or some future event. The confirmation bias causes the perception or interpretation of information in a way that will *confirm* hypotheses that already exist. At the same time, this biase can prevent the realization that the new data do not support the existing hypotheses.

2.4.5 OVER-CONFIDENCE BIAS

A large component of any analyst's job is to summarize complex ensembles of information into dichotomous judgments. For instance, an analyst might have to decide whether a particular set of maneuvers are exercises or the early stages of an attack. Or, on the basis of personal impressions and reports, an analyst might have to decide whether a particular informant is or is not competent.

An important aspect of such judgment tasks is the degree of confidence that accompanies them. That confidence may determine whether or not more information will be gathered, or whether an action will be taken.

In general, there is a tendency to be overly confident in their ability to make those types of judgments. Even with minimal information about a topic, there is a tendency to generate a great number of hypotheses concerning a judgment task without testing these hypotheses properly. Over-confidence in judgments has been found to be the rule, rather than the exception. Such over-confidence may lead to premature cessation of information gathering and to ineffective decision making The most effective way to overcome this type of bias is to be aware of it.

2.4.6 THE OVER-SENSITIVITY TO CONSISTENCY BIAS

Internal consistency in a pattern of evidence is a major determinant of confidence in judgments based on that evidence. In one sense, consistency is an appropriate guideline for evaluating evidence. Alternative explanations or estimates are formulated and one selected that encompasses the greatest amount of evidence within a logically consistent scenario.

Under some circumstances, however, consistency can be deceptive. Information may be consistent only because it is redundant, in which case many related reports may be no more informative than a single one of them. Or it may be consistent only because the information came from a very small sample or a biased sample.

When working with a small but consistent body of evidence, analysts need to consider how representative that evidence is of the total body of potentially available information. If the analyst is stuck with only a small amount of evidence and cannot determine how representative the evidence is, confidence in judgments based on this evidence should be low regardless of the consistency of the information.

2.4.7 THE RELIABILITY BIAS

There is a tendency to deal with information at face value, regardless of the reliability of that information. There are many reasons why information may be less than perfectly reliable: small sample size that is not representative of the totality of the information; misperception or bias on the part of the source; distortion in the reporting chain; misunderstanding or misperception on the part of the analyst. Further, some of the information used in analysis is retrieved from the analyst's memory, and the degree of reliability originally attributed to the information may have been long forgotten.

Analysts generally must consider many items of information with different degrees of reliabi[illegible] that are related in complex ways. It is unlikely that the analyst can make neat mathematical or even intuitive calculations that take all reliability factors into account. There seems little the analyst can do about this problem short of breaking the problem down in a way that permits assigning probabilities to individual items, and then using a mathematical formula to integrate the separate probability judgments.

2.4.8 THE DISCREDITED EVIDENCE BIAS

Impressions tend to persist even after the evidence that created those impressions has been fully discredited. When evidence is received, there is a tendency to postulate a set of causal connections that explains the evidence. Even though the evidence may subsequently be discredited, the causal links remain plausible even in the absence of the now discredited evidence.

Consider the example of an analyst receiving information from a clandestine source. The analyst may have formed a number of favorable impressions on the basis of earlier reports from this source. When the analyst finds out that the source is under hostile control and that the received information is probably unreliable, the analyst will tend to rationalize earlier impressions by arguing that the information is true despite the source being under control, or by doubting the validity of the report claiming the source to be under control. In the latter case, the phenomenon of "impression perseverance" may itself affect evaluation of the evidence that supposedly discredits the impression; this is due to a tendency to retain initial impressions concerning the validity of information an[illegible] disbelieve new evidence that contradicts the initial impressions.

2.4.9 *ANCHORING*

Anchoring is one strategy that people seem to use intuitively and unconsciously to simplify the task of mentally processing complex information. Some natural starting point is used as a first approximation to the desired judgment.

This issue is particularly relevant when moving into a new work setting and taking over responsibilities from a predecessor. The predecessor's analytic estimates become a starting point. This starting point is then adjusted, based on the results of additional information or analysis. Typically, however, the starting point serves as an anchor or drag that reduces the amount of adjustment made, so that the final estimate remains closer to the starting point than it ought to be.

Anchoring is a particularly difficult bias to avoid. Analysts may attempt to ignore their previous work or others' earlier judgments and re-think the problem through. Time and information constraints may preclude using this solution. An alternative solution might be the use of formal statistical procedures. Bayesian statistical analysis, for example, can be used to revise prior judgments on the basis of new information in a way that is designed to avoid the anchoring bias.

2.5 Memory Aids

2.5.1 *AUTOMATED AIDS AND MEMORY LOAD*

The information resources and variables in analytic work settings are usually quite complex. The loads imposed on internal memory are lessened by automated and non-automated memory aids such as computerized maps, data bases and other reference materials. Such external aids have advantages. The externalized information models they contain (templates, doctrine, IPB, etc.) do not suffer from memory modification and judgmental distortion factors that affect models stored in the analyst's cognitive memory. Unfortunately, such materials are costly to produce, slow to update compared with the analyst's internal storage memory, and usually provide only a partial match with the realities toward which they are aimed.

Apart from the potential analytic value of automated memory-aid materials, their handling and use can pose some problems for the analyst. Passive versions of such supports, which must be remembered and activated to be of use, can sometimes contribute to an analyst's memory load in locating materials. Active versions of such supports (such as alarms, forced displays, flashing prompts, rigid reminder schedules, etc.) can create interruptions, distractions, and procedural overload, by diverting the analyst's limited capacity for attention. This is more likely when the memory aid is used for higher-order processing of extensive stored intermediate results (problem-solving operations). On the other hand, active supports might prove valuable to analysts during times of stress.

2.5.2 *TEAM MEMORY*

An external memory resource widely used by analysts -- especially under trying circumstances -- is the "team memory" represented by colleagues. Team memory is invaluable as an external memory supports for several reasons:

- *Query formulation* is comparatively easy; a colleague can not only provide information, but can help the analyst define a need and frame a query in terms understandable to the colleague.
- *Rapid response* is available; a colleague can quickly indicate whether or not any help can be expected. This allows the analyst to search widely in a short time if necessary.
- *Rapid update* of colleagues' memory contents can be achieved under some conditions for which materials-based memory support systems would require considerably more time.
- *Self correction* of memory resources is somewhat automatic, since colleagues tend to recognize their memory shortcomings and try to correct them. While materials-based memory support systems could, in principle, be designed this way, it is not likely to be realized in the near future.
- *Active problem solving* by colleagues is frequently included as part of the team-memory services to one another; relevant memory contents are not only located and communicated, but also compared, placed in contexts, and evaluated.

The one disadvantage that may result from the use of team memory is that colleague tasks may become disrupted. This is often an inescapable result of using team-distributed memory. The availability of team-distributed memory cannot be guaranteed under conditions of high organizational work load, unless extra personnel have been planned for such functions.

3. CONCEPTUAL MODELS

While the functional bases of memory and information processing are described in terms of the structures and processes described in the previous chapter (i.e., active memory, episodic, semantic/factual), the unit of memory contents is represented by the conceptual model.

Conceptual models are also functional units in the sense that they represent the *active, currently available* contents of memory that determine what information is perceived and how it is processed. The "what" and the "how" of information processing varies depending on the contents, the complexity, and the recency of the conceptual model that is in active memory at the time information is perceived. The values of the conceptual models' parameters (e.g., complexity and size) determine the ease or difficulty of learning and remembering new information. As a result, they have an important impact on the design of training materials. For example, training materials for new analysts must be designed quite differently than training materials used for the maintenance of the established skills of experienced analysts.

The characteristics of the conceptual model also impact on the quality of communication between people. Since communication is a pervasive problem, the implications derived from specifying the nature of conceptual models and shared conceptual models can make a significant difference to the analytic community.

3.1 The Nature of Conceptual Models

Learning always occurs within a given context, that is, within the context incorporating the learning material. This context is called a conceptual model. The important point about conceptual models with respect to learning new information and with respect to communicating with others, is that conceptual models have parameters that have different values as a function of the amount of knowledge the person has in the target area.

Conceptual models (CMs) are coherent systems of knowledge that are used to assign meaning to the environment, to think, to remember, and to solve problems. CMs serve as blueprints for aggregating large amounts of intelligence information into meaningful higher-order units. The use of CMs as information chunking devices provides one method for circumventing the limited capacity of active memory (see Section 2.1).

Each element of stored knowledge is associated with one or more conceptual models; i.e., a person's memory does not contain stray bits of data that have no connection to any type of context. It is the context, i.e., the conceptual model, that determines how easily new information will be learned, how quickly it will be forgotten, or how new information will alter existing knowledge. For example, if a person knows a great deal about a particular topic, new information associated with that topic will be learned much more easily than if the topic is unfamiliar. Implicit in that statement is that training materials must be presented differently in the two cases.

Conceptual models are generally organized by subject matter. Typically, humans have CMs concerning all topics that they have learned about over their lifetime.

Obviously, the amount of knowledge about each topic varies and has different degrees of relevance to the person in question. The way CMs are characterized has important implications for understanding and predicting how people learn, solve problems, and communicate with others and hence, has implications for the design and development of training materials for intelligence analysts.

The characterization of conceptual models by parameter values also makes it possible to hypothesize how the memory mechanisms described in the previous chapter (e.g., filtering, assimilation, or interference) influence information processing (Weichel, 1972). It is likely that various cognitive biases are differentially detrimental as a function of the parameter values of the conceptual model in use at the time. Intelligence analysts must constantly be aware of the various cognitive biases that can distort their analytic findings. Understanding the bases for cognitive biases can mitigate some of the circumstances under which analytic errors can occur. Understanding the differential effects of cognitive biases as a function of specific conceptual models can alleviate some of the need for this constant vigilance.

There are different *types* of conceptual models. For example, conceptual models for language or for storing temporary information are quite different than conceptual models that deal with factual knowledge. The present document deals only with conceptual models that are made up of factual and conceptual information as used by intelligence analysts.

Intelligence analysis involves the assignment of meaning to new inputs combined with previously stored information. This process is largely concept-driven (Norman & Bobrow, 1975) in that the analysts' goals, hypotheses, and knowledge of the world dictate information collection priorities and processing/interpretation strategies and biases. Each analyst has his or her own stored conceptions of the world that guide concept-driven processing.

Both semantic/factual and active memory are organized by conceptual models. CMs are stored in semantic/factual memory, but must be transferred to active memory before they can be used to interpret external or internal stimuli. Information processing (including learning, forgetting, and reorganization of existing information) produces a change in the active CM. Information in active memory is considered to be dynamic and to become reorganized with new inputs (Hopf-Weichel, 1977), whereas information stored in long-term memory (semantic/factual or episodic) is considered to be latent. This view has implications for intelligence analysis in that it impacts on the functioning of attention and vigilance. For example, environmental stimuli that are not related to an active CM will tend to be ignored. Many cognitive biases can be interpreted and understood within this framework.

Because of the role of CMs as information chunking devices, an understanding of their contents and characteristics can greatly facilitate the development of effective training materials.

3.2 Characteristics of Conceptual Models

Conceptual models can be visualized as sets (in the set-theoretic sense) that overlap in varying degrees. The elements of these sets include:

- Items of information (e.g., background knowledge concerning the geography of a particular country).
- Relationships among items (e.g., effect of weather on mission effectiveness).
- Goals (e.g., national security, winning the first battle).
- Plans for behavior (e.g., what information to collect to achieve goals).
- Sequences of behavior (e.g., the best way to collect information).
- Time relationships (e.g., when a message was received, or when a particular informational item must be available for processing within a given timeframe).
- Access to other CMs.
- Knowledge concerning the contents of other people's CMs. This is important in that it allows one to optimize the benefits of shared conceptual models (see Section 3.4).

Conceptual models can be characterized in terms of a number of different parameters, with the value of each parameter varying depending on the CM involved. Some of these parameters include:

- SIZE. This is an indication of the amount of knowledge associated with the particular CM. The higher the value, the more is known about the subject matter of the CM. In general, the larger the CM, the easier it is to add new items. Increases in size come about when new information is added to an active CM (i.e., a CM that is in active memory) or when information from two or more CMs are combined.
- COMPLEXITY. This is an indication of the degree of structural complexity among the items within a CM. This, in turn, indicates the amount of understanding associated with the topic of the CM. "Understanding" subsumes a knowledge of interrelationships among items, their influences, and potential consequences for future events. In general, a higher value on "complexity" is associated with greater problem-solving and decision-making abilities with respect to the CM.
- NEWNESS. This refers to how recently a CM has become established. For example, an analyst who has recently been transferred to a new country area has a newer CM for that area than an analyst who has been in the area for several years. In contrast to well-established CMs, the newer the CM, the greater the probability that items associated with a new CM will be forgotten. In general, new CMs will have slower learning rates than well-established CMs.
- FREQUENCY. This refers to how frequently a CM is entered into active memory and is the basis for practice effects. A new CM used frequently rapidly becomes a well-established CM. In general, infrequently used CMs (e.g., as when an analyst only passes through a country two or three times, rather than being assigned to it), will be associated with more forgetting and slower learning rates.
- "AFFECT". Some topics are of more interest and/or are more important to a person than others. Such topics have a higher "affective value", which is associated with higher motivation, attention, easier learning, and better retention. CMs with higher affective values also tend to have better defined goals than CMs with lower affective values.

- PLAS.,CITY. This is related to the dynamic nature of information stored in active memory. Plasticity is a parameter that tends to be invariant over all CMs of a given individual, but tends to vary across individuals. It refers to the fact that some individuals are more easily able to reorganize information within and between CMs than other individuals. A high value on plasticity is associated with creativity, as when a new solution is found to a problem because the new solution is simil to one that applies in a completely different context.

The parameter values for any given CM tend to be highly correlated with each other and tend to determine how well or easily information associated with it is learned, processed, and retrieved. This has an impact on the development of training materials, on the issue of automation, and on the development of shared conceptual models which form the basis for effective communication.

New conceptual models can be formed in a variety of ways:

- By reorganizing existing CMs.
- By being faced with an important goal or problem for which no adequate know lge (background, specific, or procedural) is available.
- By perceiving stimuli (events, behaviors, physical shapes, etc.) in ones environment that have no meaning within one's own conceptual framework. In general, however, unfamiliar or strange stimuli are simply assimilated within existing CMs (see Section 2.1), hence the differences among peoples' perceptions (and later recall) of the same situation or event. These differences in perception lead to misunderstandings and poor communication.

3.3 Knowled- Base Taxonomy for Intelligence Analysis

Conceptual ls are made up of various types of knowledge that are stored in semantic/fact. memory. Information from the environment is interpreted and altered in acti memory when it activates or otherwise interacts with a CM. This is true no matter how simple the environmental information, and no matter how simple the transformation. It is important, therefore, to identify the information that comprises the ana sts' and the users' CMs.

A taxonomy of knowledge (see Figure 3-1) was developed based on a composite of answers obtaine on-the-job interviews with analysts, conducted during the IMTIA project. This taxonomy does not represent an exhaustive listing of the information encompassed by CMs. One major concern was to determine what types of knowledge are required for analysts to perform effectively and how the presence or absence of one type of knowledge or another might affect performance.

The results of the analyst interviews were categorized into a taxonomy of knowledge comprising three types of information:

- *Specific knowledge* refers to the knowledge necessary to interpret specific environmental information and includes the meaning of input messages, electronic signals, or imagery, for example. These are typically discrete elements that may or may not form a pattern but that do have a representation in memory.
- *Background knowledge* refers to the knowledge required to interpret specific information within the analytic *context*. Background knowledge includes

KNOWLEDGE TAXONOMY FOR THE ANALYST

Background Knowledge	Specfic Knowledge	Procedural Knowledge
Military Science (Doctrine)	Messages	Communications
Science and Technology	Events	Memory Access
Sociocultural Information (ethnography, language)	Patterns	Threat Modeling
Sensor Mode Information	Clients	Decision Making
Geography	Specific Codes	Information Gathering
	Values	Hypothesis Testing
		Journalizing

Figure 3-1: Knowledge Taxonomy for Intelligence Analysts.

information about a particular territory; for example, its geographic, ethnographic, or doctrinal characteristics. Information concerning users, missions, and goals are also aspects of the background knowledge of an analyst.

- *Procedural knowledge* includes the rules that are used during interpretation (such as rules for constructing meaning, for drawing inferences, and for making decisions) as well as the cognitive tools and methodologies used by analysts.

3.3.1 *SPECIFIC KNOWLEDGE*

Specific knowledge refers to the ongoing flow of information that an analyst has to process. In processing such information, analysts look for meaning and patterns in the context of their background knowledge. The characteristics of these patterns contribute a great deal to the reliability and the validity of the final intelligence product. These patterns must be characterized in terms of measurable attributes if performance on pattern recognition and interpretation is to be evaluated and training enhanced.

Informational patterns have attributes that have differential impacts on analysts' interpretations and inferences. The specific set of attributes may vary depending on the task and the goal, but interviews with analysts indicate the following attributes as relevant to understanding an information pattern:

- Novelty (old versus new patterns) - This attribute refers to whether or not an analyst has experienced a particular pattern before. A new pattern may have little *a priori* meaning associated with it, compared to an old pattern, and this will impact on how the information is used by the analyst. In general, an old pattern would tend to lead to a more reliable intelligence product than a new pattern. On the other hand, a new pattern may lead to more creative hypothesis- generation, and could possibly lead to a more valid product. Further, an old pattern may lead to overselectivity in information processing (see Section 2.2.1), and thus be subject to a confirmatory bias.

- Sparsity (rich versus sparse data) - This attribute refers to the number of elements in a pattern. Analysts dealing with sparse data must make more inferences concerning the meaning of those data. This tends to lead to a product that has a great deal of uncertainty associated with it. In particular, sparse data might lead some analysts to exaggerate unusual aspects of the data, thereby resulting in the caricature effect (see Section 2.2.2)

- Congruity (congruous versus incongruous information) - This attribute is based on the assumption that information patterns represent the basis for generating hypotheses concerning the state of the world. A congruous pattern contains elements that all tend to point to a single hypothesis. An incongruous pattern can occur in one of two ways: either the elements suggest more than one meaning, which can give rise to several plausible hypotheses, or the elements tend to suggest contradictory hypotheses. Obviously, congruity in the informational pattern leads to a more valid and reliable product than incongruity. A congruous pattern can also be processed faster.

- Risk (high versus low risk) - This attribute refers to whether or not the pattern suggests that the environmental situation is risky. This attribute is important because it may imply time constraints on the performance of the task, and it may induce cognitive stress, which could represent a source of errors. The risk factor is obviously an important attribute in developing threat models, but it is not clear whether or not it has an effect on the validity or the reliability of the product.

- Definition (well-defined versus poorly defined) - This attribute refers to the concreteness of the meanings associated with the elements within a pattern, as well as with the meaning of the pattern itself. A well-defined pattern is more likely to lead to a valid and reliable product than a poorly defined pattern. An analyst's repertoire of well-defined patterns (e.g., templates) is expanded through the acquisition of background knowledge described in the next section.

There are a number of issues concerning specific knowledge that should be understood. The first is that the representation of specific knowledge is dynamic. That is, the information that is being received is constantly changing, so that knowledge from memory that is brought to bear in assigning meaning to this information has to be continually updated. This has significance for the way this type of information is represented in memory. The second issue is that the representation of specific knowledge is likely to be much more complex for multi-source than for single-source analysts, since multi-source analysts deal with much more diverse information than single source analysts.

3.3.2 BACKGROUND KNOWLEDGE

Background knowledge provides the framework for assigning meaning to specific informational events. Perception of real world events never occurs in the abstract, but always in terms of what is already known, i.e., what is stored in episodic and semantic/factual memory. The greater the similarity of different analysts' background knowledge, the higher the probability that events will be interpreted the same way, a consideration that will be important in evaluating performance. It must be noted, however, that even though perception and interpretation of environmental information is a function of the contents of episodic and semantic/factual memory, these processes occur only after a sub-set of the available knowledge is loaded into active memory. That is, the analyst must activate the appropriate knowledge base (CM) for that knowledge to be of value.

The characteristics of the background knowledge are particularly important in determining the complexity and appropriateness of an analyst's CM, since it is assumed that the way meaning is assigned determines the way information is processed. This is very much dependent on the complexity of the conceptual model, which in turn is highly correlated with the characteristics of the background knowledge as stored in memory. If the background knowledge is extensive in a particular area of expertise, it is easier to learn new items of information associated with this area, than if it is not well developed. Therefore, the characteristics of the background knowledge also determine the rate of learning, as well as the way learning is transferred. Other characteristics include the idea that the rate at which the background knowledge changes (increases or decreases), compared to other types of knowledge, is relatively slow. This imposes constraints on how procedural knowledge is used and it has the potential of creating biases such as tunnel vision.

A specific example involves the problems encountered by analysts when they are transferred from one theater of operation to another. The background knowledge required to process information (specific knowledge) in the new area is necessarily different than the background knowledge the analyst transfers from the original theater of operation. However, building up a base of background knowledge takes time. Until this background knowledge is built up, the analyst may experience difficulties in assigning meaning to the specific knowledge. The analyst may also face problems if the available procedural knowledge is not directly applicable to the new environment.

One fruitful area for automation is in the area of background knowledge. As just seen by the example, the judicious use of external memory could do much to alleviate transfer problems. Background knowledge is one aspect of pre-processed knowledge, and external memory can be considered as one aspect of background knowledge, *if* it is accessible. Training considerations must include how to optimize the acquisition and accessibility of background knowledge, whether through internal or external memory.

Four types of background knowledge relevant to analysis are:

- Military science
- Science and technology
- Sociocultural knowledge
- Sensor mode knowledge

Background in each of these areas aids the analyst in performing most analytical tasks. Commonalities and differences in knowledge requirements for different analytic specialities are highlighted below.

a. Military Science

Commonalities between SIGINT, HUMINT, IMINT, and FUSION specialties include an extensive knowledge of military science areas including Order of Battle and military geography. Characteristically, this knowledge is acquired in specific relation to the targets and geographic area within the analyst's assigned area of responsibility. The analyst gradually expands this knowledge base by cross-training or reassignment to other intelligence production facilities.

b. Science and Technology

Most specialties of intelligence analysis use almost all forms of physical science and technology. A strong technical background helps the analyst understand what is seen or heard in data collected from technically complex targets such as aircraft, missiles, radars, communication nets, factory complexes, and the like. The complex workings of weapons systems, communications, command and control organizations and procedures, and electronics systems must be understood for proper interpretation of intelligence data in both strategic and tactical missions.

Emphatically, this principle holds for all levels of intelligence analysis as defined earlier. Although the inexperienced image interpreter performing a target location or counting function requires much less general knowledge and understanding than an analyst with a more explicit evaluation role, all levels benefit by a thorough understanding in their area of responsibility. The analyst expands this area of knowledge through exposure to new systems and through on-going interests in technical areas and activities.

c. Sociocultural Knowledge

Knowledge of a target country's culture is valuable in discriminating militarily significant items from non-significant ones. Ethnography helps the analyst know where to look for significant items and what to filter out. Sociocultural knowledge is particularly important in strategic intelligence analysis where the use of economic, political, and industrial models may be involved.

d. Sensor Mode Knowledge

Because the entire intelligence production cycle is included in the scope of intelligence analysis activities, the ability to understand the capabilities of sensor systems is a fundamental knowledge requirement. Although an imagery interpreter may not need to know how a particular camera works, the constraints under which photographic data is collected must be understood when making decisions about collection plans and the quality of intelligence products.

3.3.3 *PROCEDURAL KNOWLEDGE*

The most important aspects of procedural knowledge are decision making skills and the implicit and explicit rules and strategies used to perform the tasks of intelligence analysis. Procedural knowledge also includes specific techniques and methods used in analytic planning, estimation, forecasting, and so forth.

Although procedural knowledge has to be learned, and experience plays a major role in its effective use, it is hypothesized that this type of knowledge is more easily transferred from one theater of operation to another, than is either specific or background knowledge. It is further hypothesized that there are fewer differences between single- and multi-source analysis in the way procedural knowledge is used than in the way other types of knowledge are used.

Procedural knowledge is valuable only to the extent that it enables the analyst to manipulate information. Although skilled individuals typically possess a large store of information about their field of expertise, there has been no strong theoretical analysis showing how the existence of a large store of information contributes to successful problem solving (Greeno, 1978).

Procedural knowledge provides a bridge between specific/background knowledge and the procedures acting on this knowledge base that enable problem-solving and task-performance activities.

3.4 Shared Conceptual Models in Communications

Shared conceptual models (SCMs) have two major components:

- Those aspects of a conceptual model that two or more people have in common, such as a language or the knowledge of a subject matter.

- Access cues and knowledge concerning the contents of another person's conceptual models. (This is the component that makes team memory and external memory effective as an extension of one's own memory.)

Communication is impossible without SCMs and analysts and the users of intelligence must be encouraged to develop SCMs concerning the analytic situation. The threat model, discussed in Chapters 6 and 7, is to be used as the main SCM for intelligence analysis.

In using SCMs, it is important to remember that these models ensure that a given input means the same to those involved in communicating about the input. They reduce the perceptual and cognitive differences between people. From this point of view, SCMs increase the effectiveness of communication by reducing the amount of time needed for communicating. On the other hand, there are advantages in the perceptual and cognitive differences that humans experience in assigning meaning to their environments. These are the differences that are responsible for richer problem-solving behavior in brainstorming sessions, for example, or that lead to more diverse hypothesis generation. The achievement of a proper balance between developing SCMs and encouraging perceptual and cognitive differences between analysts is a matter for further research. In general, however, shared conceptual models should be encouraged for an optimal analyst-client relationship.

Without prior conceptual preparation, communications during battle would have to be fully elaborated in order to convey full meaning, and for all participants to have a complete understanding of their tasks and the goals of the mission. Under such conditions, SCMs would be minimal, and the only way to ensure accuracy and a complete understanding, would be through direct feedback. On the other hand, if battlefield participants take prior care to develop SCMs, the amount of needed data flow for battlefield communication can be curtailed.

Many communication errors are the result of interpreting information within one's own personal context or CM, which may either be wrong for the given situation, or may simply be different than that of the communicator. Thus, an additional, and very important by-product of SCMs, is a reduction in communication errors and misunderstandings, since SCMs include context as a shared factor.

In promoting the development of SCMs, there are issues for the analyst to consider, as well as issues for the user of intelligence.

Issues for the analyst:

- What does the user know?
- What does the user need to know?
  - What information should be left out?
  - What information should be included?
  - What level of detail should be presented?
  - Frequency of update/refresh known information?
- How does the user react to uncertainty?
- How should uncertainty be conveyed?

- Has the transmitted message become part of the SCM? (Has it been clearly understood by the user?)

Issues for the user:

- The user must remember to provide feedback to the analyst that gives the analyst the following information:
  - The user's perception of threat.
  - The user's reaction to uncertainty.
  - The user's reaction to new information:
    - Is it adequate?
    - Has it altered the perception of threat?
    - Has it become a part of the SCM?
    - What additional information is needed?

Issues for both the analyst and the user include the need to develop a shared understanding of the meaning and interpretation of uncertainty and of probability estimates.

There are many research and development issues, as well as training implications, associated with the concepts of conceptual models and shared conceptual models. These will be discussed in Chapter 9 of this document.

4. SKILL REQUIREMENTS FOR INTELLIGENCE ANALYSIS

In Chapters 2 and 3, the theoretical bases for intelligence analysis were described, including the cognitive structures and processes that comprise the cognitive model. During the IMTIA interviews with intelligence analysts and as a result of examining analysts' answers, work environments, tasks, and missions, Logicon researchers found that there are certain basic skills that all good analysts possess. These basic skills comprise general analytic skills which, when combined, serve to fulfill the two primary goals of an intelligence analyst, namely:

1. **To reduce uncertainties for the users of intelligence.**
2. **To maximize the use of scarce resources.**

These two goals serve to increase the amount of control that the users of intelligence have over the threat situation. To increase the probability of fulfilling the analytic goals, the following four basic skills are required:

- Conceptual modeling.
- Information triage.
- Decision making.
- Effective communications.

4.1 Conceptual modeling

The structure of conceptual models was described in Chapter 3. Conceptual modeling is also a general skill for analysis in that it forms the basis for effective triage, decision making, and effective communications. Conceptual models are the means by which the analyst organizes, stores, and maintains the extensive knowledge base that is required for intelligence analysis. Conceptual models provide the base for:

- Interpretation of sparse data.
- Fill-in of missing or inaccurate data.
- Comparison of alternatives.
- Communications.
- Predictions.
- Access to external memory.

Among the many different skills subsumed by conceptual modeling, pattern analysis and recognition are particularly important in intelligence analysis.

During normal perception, the human cognitive system routinely "filters" out most of the millions of bits of sensory data reaching the sense receptors; yet despite this filtering, visual perception is relatively efficient. One reason for this is the degree of redundancy in the input data stream, and the fact that the human cognitive system is able to reconstruct from long-term memory aspects of a percept that may not be directly available from sensory data. The intelligence analyst faces a more difficult task, however, because the amount of redundancy in the data is not known. Yet, as in the case of visual perception, analysis can be efficient if the relevant conceptual model (CM) can be retrieved from long-term memory. This can then be used to "fill-in" the parts of the "intelligence picture" and direct information selection along other paths and different sources.

Intelligence analysts are often involved in routine, rule-based recognition that probably occurs "automatically" as the incoming information is found to fit the analyst's CM more and more closely. The CM, which is multi-faceted and frequently contains numerous related schemata or templates, imposes meaning on the incoming information according to the analyst's experience, intentions, motivation, and goals, and is activated by the incoming messages. But what happens when the data do not fit any of the information within the CM? Or if the situation is so puzzling that no CM suggests itself? Which CMs are activated, or which schemata within the CM are developed in this case? The development of the appropriate schema structure is dependent upon a number of non-attentional factors, such as the analyst's knowledge base, effectiveness of memory search, etc. However, attentional factors are important in two ways: (1) in the "intensive" sense of attention; that is, effortful processing and consideration of message features and combinations of features. Successful analysis demands active, memory-driven application of attentional resources to the development and testing of an appropriate CM. (2) The development of the appropriate CM is dependent upon the selection of the correct information sources (through an attention allocation policy, and appropriate chunking, as suggested above) while the selection policy is itself influenced by the initial, fragmentary CM that the analyst possesses.

Consider the analogy of solving a jigsaw puzzle. If the picture of the completed puzzle is provided then a schema already exists to direct the search for particular pieces, and the successful completion of the puzzle merely requires the matching of individual pieces with parts of the given picture. If no picture is provided, the puzzle is more difficult (although by no means as difficult as the puzzles faced by analyst's). One must examine a piece or group of pieces for *context* clues so that an initial conceptual model can be developed. This model then directs the search for particular pieces, some of which might lead to the rejection of the initial model and the development of another one, in a feedback loop. The conditions under which this feedback loop leads to successful analysis or results only in a "vicious circle" are unknown. Furthermore, the analyst faces another problem that does not arise with jigsaw puzzles. With jigsaw puzzles (as with all other puzzles), one knows that there must be a solution. Suppose, however, that a perverse toy manufacturer were to market a jigsaw puzzle of an abstract painting and not show the "correct solution"; then the completed picture would vary in as many ways as one's concept of what abstract art should look like. The analyst's task lies somewhere between the extremes of this situation and that of the standard jigsaw puzzle with a given picture. A "solution" is possible only insofar as the final pattern "makes sense", or is thought to be probable.

Performance in the above-mentioned situation is limited by attentional factors. First, even though the analyst's conceptual model and therefore his search strategy may be appropriate, the fact that he can only direct his attention to certain items at any one time may mean that on certain occasions an item necessary to confirm a particular hypothesis is missed. Second, research on the cognitive psychology of problem solving has shown that if certain critical cues are not attended to during the early phase of problem solving, the likelihood is that they will not be picked up later so that the probability of correct solution is small (Wickelgren, 1974). Since the capacity for sustained attention for critical cues is likely to drop with time, successful pattern recognition requires that attention be directed to the relevant cues as soon as possible in the analytic cycle.

Perceptual skills are especially important for single-source intelligence production. There is a strong consensus in the field that the perceptual skills fundamental to SIGINT and IMINT single-source production must be developed by using real data. That is, the refined perceptual skills necessary to interpret particular kinds of images or to recognize certain voices of certain morse or telegraphic operators cannot be fully developed in exercises dissociated from real targets.

Familiarity with particular target areas increases analysts' effective use of perceptual and cognitive skills, their confidence and speed in interpretation, and their ability to detect significant changes. A substantial time period is required to gain such familiarity even for experienced analysts. SIGINT analysts typically state that it takes two to six months to adapt to a new target area after being reassigned. IMINT analysts are often semi-permanently assigned by geographic area and/or target types in order to take advantage of the resulting accumulation of perceptual familiarity.

4.2 Information Triage

Information triage is the means whereby the mass of available information is sorted for relevance. Information overload is a formidable problem for the analyst dealing with the target-rich modern battlefield and modern collection systems. The unprepared analyst could easily be inundated by message flow and be unable to perform effectively.

The relevance of information cannot be defined in the abstract. Rather, it has to be defined in terms of the goals and subgoals of the intelligence community, the various echelons within Army intelligence, and the specific job of a particular intelligence analyst. How relevance varies according to the goals of a nation is described by Codevilla (1980), in a paper dealing primarily with the type of organization required for effective intelligence analysis. However, both the organization and the relevance of intelligence data are shown to relate to the needs and goals of different governments. As Codevilla points out:

A nation engaged in political or military offensives has a different analytical problem than a nation on the receiving end of such offensives. A government that does not believe it is in danger of military defeat is likely to focus its analytical efforts differently than a government that believes such a defeat is possible.

This quote highlights the importance of goals in determining the mission requirements and the relevance of the information needed to fulfill those requirements. Numerous other factors influence how relevance for information triage is determined. For example, the process of triage depends on the availability of resources, the requirements of specific users, and the work setting context. Its successful completion is a function of the more specific skills of attention in information selection.

There are several varieties of attention, all of which share in common the idea of conscious processing of information. Here, the source of information may be external (data-driven) or internal (memory-driven) (Kahneman, 1973; Norman and Bobrow, 1975) The different components of attention may be thought to differ along two dimensions, the *intensive* and the *directional*. Attention can be directed to one or other source (internal or external), and it may be deployed with more or less intensity. Listed below are other dimensions by which different varieties of attention may be identified:

- Source: Focussed or Divided Attention.
- Processing Resources: Required (Controlled) or Not (Automatic).
- Duration: Transient or Sustained Attention.

Analysts develop appropriate attention allocation policies that determine how they select information from the stream of input data they process. One such policy may be to attend only to high information-value or high-probability sources. Under normal conditions, this implies that low-value sources may be "filtered out" without serious consequence. Under stress conditions, these low-value sources are ignored; thus in non-routine conditions, where "low-value" sources carry important information, errors may result.

From interview data gathered from intelligence analysts, we have concluded that intelligence analysis is predominantly concept-driven rather than data-driven. This conclusion was reached after observing the extensive memory resources that analysts bring to the production of most intelligence products, and noting that much of the memory-based information was conceptual in nature. The production process is also concept-driven in the sense that intelligence products can be, and often are, produced in the absence of any data. Intelligence preparation of the battlefield (IPB) is an example of an activity that depends almost entirely on previously developed and stored knowledge. As indicated earlier in this report, highly experienced and effective analysts often appear to organize the mental storage of such knowledge around conceptual models. The analyst's ability to deal with conceptual models grows as a result of experience in learning abstract concepts. The superior analyst is one who carries out data aggregation in a manner likely to lead to the detection of a significant pattern. He does not have access to more or better information than the less able analyst, but is better able to chunk the available items of information (including "items" drawn from memory) into significant wholes. This implies that "bigger and better" information collection systems do not necessarily result in better analysis.

4.3 Decision Making

Decision making is a general skill that underlies almost all information processing. While decision making can be performed by following prescribed normative procedures, any analytical decision making activity must be managed and regulated by the goal hierarchy of the intelligence community.

While analysts do not make command decisions, critical decisions are made at all levels of analysis, especially decisions to include or exclude data from analysis. Analysts are constantly called on to make decisions regarding what, how, and when information can be used to support strategic or tactical decisions made by the users of this information. Despite this critical role, analysts are generally not trained as decision makers.

Analytic decision-making involves a set of unique, complex, and demanding information-processing and problem-solving tasks. Typically, the decision maker must gather and evaluate various sources of evidence and enumerate possible hypotheses, analyze the consequences of particular decisions, and make recommendations where necessary on possible courses of action. Almost always the information needed to make reliable decisions is insufficient, even when augmented by memory or decision aids, and the possible options open to the decision-maker are not clearly specified. The critical nature of this difficult task is heightened when the time available for making decisions is limited, when the task has to be performed under other stress-inducing conditions, and when the courses of action are associated with high risks.

4.3.1 CONCEPTUAL STRUCTURE OF DECISION-MAKING

Any decision-making task, no matter how simple, can be divided up into two basic stages:

- Problem Structuring
- Alternative Selection

In the first stage the possible hypotheses under consideration bv the decision-maker are identified and assessed, or, if initially unavailable, created (hypothesis generation). In the second stage choices between hypotheses or possible courses of action are made.

Although this distinction has been recognized for some time, the problem structuring and hypothesis generation phases of decision-making have been comparatively neglected in the research literature. Both of these are important aspects of decision-making in intelligence analysis. Katter, Montgomery, and Thompson (1979), who conducted several in-depth interviews with intelligence analysts involved in both single-source and multi-source intelligence activities, found that analysts view themselves as "detectives" or "historians" faced with the problem of solving complex "puzzles" and "mysteries". Before detectives or historians can solve a particular puzzle, they must think about the problem, formulate some analytical structure, and develop possible hypotheses or solutions. Only then can they profitably evaluate the evidence and begin to arrive at the most satisfactory solution. Although intelligence problems rarely have "perfect solutions", successful intelligence analysis also begins with the recognition and structuring of a decision problem.

4.3.2 PROBLEM STRUCTURING AND HYPOTHESIS GENERATION

Problem structuring consists of translating the decision problem into a formal structure by relating the aspects of the problem to the elements of a formal model.

Keeney and Raiffa (1976) identify problem structuring with the complete specification of decision choices and objectives. Edwards' (1977) so-called SMART model, for example, consists of a set of choices available to the decision-maker, a set of objectives, and a set of attributes with which the choices are evaluated; in addition there are several criteria that these sets need to satisfy. SMART is an additive, riskless model of multiattribute preferences; it was found to be useful for modeling certain aspect of public utility measurement in social decision-making. Like other models, however, its analytical accuracy depends on a number of assumptions. The major difficulty arises in ensuring that all aspects of the decision problem and all elements of the model have been adequately specified.

All problems can be structured and analyzed using a general model comprising four components:

- All problems begin with an *initial state*. This is the condition of things when the problem is recognized and the task is to recognize all the relevant factors pertaining to the initial problem state.:
- All problems have a *goal state*. This is the condition of things when the problem is solved. It is the desired end state and the task is to identify the differences between the initial and the end state on the relevant factors.
- Progress is made from the initial state to the goal state by way of the *solution path*. The solution path is the sequence of steps to be followed to achieve a solution. There may be more than one solution path and the task is to identify which may be the best for the problem, especially when resources (e.g., time) are scarce.
- The elements of the problem are embedded in a *context*. The context may include parallel problems, resources available, country areas, and overall, guiding goals of the analyst or the user.

This general problem-solving model is simply a structuring tool used in conjunction with the structuring and generation of hypotheses.

Hypothesis generation is a process that ideally requires the decision-maker to generate a set of all possible hypotheses that pertain to the problem. In general, however, most persons have a great deal of difficulty in doing so. Gettys and his colleagues have reported a number of studies showing that the hypothesis set developed is most often deficient (not exhaustive), and that too few hypotheses are retrieved from memory (Gettys and Fisher, 1979; Mehle, 1980). Mehle (1980) found that both experienced mechanics and novices had difficulty in generating complete hypothesis sets in response to a decision task concerning a non-functioning automobile. Both groups of subjects were also overconfident in their subjective estimates of the probability of any hypothesis in their hypothesis set.

These phenomena apply equally to naive observers as they do to intelligence analysts or other expert decision-makers. An analyst will arrive at a hypothesis with little or no data. Subsequent information gathering tends to increase the analyst's confidence in the original hypothesis rather than the accuracy of the hypothesis (Heuer, 1978).

The all source analyst has particular difficulties in hypothesis generation and evaluation, compounding the overall problems underlying decision-making. Some of these additional problems include:

- Hypotheses have already been generated by the information sources (normally by other analysts).
- Hypotheses were generated when the collection plans we:e formulated.
- Hypotheses were made when previous data were collected.

All of these difficulties may limit the hypothesis generation capabilities of the analyst and, in order to overcome these limitations, the analyst may be forced to revert to the original source data and formulate a new hypothesis.

Although something is known of these and other factors that limit hypothesis generation, the underlying processes themselves are not fully understood. Gettys and Fisher (1979) propose that hypothesis generation involves retrieval from memory from possible states of the world, the retrieval cues being elicited by the initial information provided. They propose that these hypotheses are rapidly checked for consistency against the remaining information. The existence of a high-speed verification process in hypothesis generation was suggested by the results of a number of studies carried out by Gettys and his colleagues.

The identification of two independent cognitive processes - retrieval from memory and consistency checking - to underly hypothesis generation is an important contribution. This two-process view may be especially applicable to the further understanding of how hypotheses change as new information is received in decision situations with multiple sources of information. However, a number of other questions concerning hypothesis generation remain. An important cognitive bias that influences hypothesis generation is the confirmation bias (see Section 2.4.4.) Persons are reluctant to seek disconfirming evidence against a hypothesis they hold, particularly if their belief in the hypothesis is quite strong. Quite often such a hypothesis might be the initial h p esis that the decision-maker thought of. Since the initial hypothesis may be very resistant to disconfirmation, it is important to understand both how initi... ...ses formed and why people tend to hold to them strongly.

4.3.3 ALTERNATIVE SELECTION

Alternative selection is one component of the decision-making task that has been extensively studied and for which normative models have been developed (e.g., Raiffa, 1968; Slovic, Fischhoff, & Lichtenstein, 1977). Here, a specific choice of alternatives (resulting from the hypothesis generation phase) is presented to someone who must then select one course of action. It is a very difficult psychological task to compare several courses of action and to select one, especially in the complex environment of intellig... ...s. First, it strains the limited capacity of short-term memory si... visu... a single alternative and its implications, let alone carry several in mind simultaneously in order to compare them. Second, if the alternatives are complex, there are no clear methods of comparison, even if the several choices can be viewed simultaneously. And third, there are always unknown factors that intrude upon the situat... Some of the results of the action are hypothetical in that there is frequent... way of knowing what will happen if such an action is selected. Some of th... ...sults of the decision may depend on the enemy's reaction to it, or on some other unknown factors.

The function of rational decision theory is to identify the information that is relevant to a decision and to specify how the information should be put together to arrive at a conclusion. The major principle of rational decision making is that of *optimization*: All other things being equal, pick the alternative with the greatest value, by no means an easy task considering the numerous uncertainties that analysts constantly deal with.

The distinction between problem structuring and alternative selection provides the key to understanding the role of aids for enhancing analytic capabilities. Biases affecting the generation of hypotheses are different from those which affect the evaluation of decision alternatives, although some biases are present in both stages. The cognitive biases influencing alternative selaction for a given set of hypotheses have been well documented. The highest pay-off would come in the exploitation of aids for alternative selection. Cognitive biases influencing the generation of hypotheses and the manner in which hypotheses are maintained and discarded are only beginning to be explored. Thus, different considerations apply in developing techniques for counteracting biases. Different decision-aid methodologies may be appropriate depending on the component of the decision problem involved.

4.4 Effective Communication

Without effective communication no intelligence activity or process can be optimally utilized. The analyst must communicate in many different ways, being dependent on communications skills for tasking, utilization of external knowledge sources, recording the analytic procedure, and product delivery. Many of the problems that currently exist in the intelligence community are related to communication problems. Effective communications must involve an understanding of the communications networks and the media available. The analyst must also know how to control the data flow for effective transfer of information.

Effective communication can be optimized by a process that involves the development of shared conceptual models. Conceptual Models (CMs) and Shared Conceptual Models (SCMs) are central to an understanding of learning, information processing, remembering, and communicating, as discussed in Chapter 3. These models are organizational systems in memory that attribute meaning to informational events and that are responsible for making communication possible. The analyst must be aware of and understand differences in the perspectives and analytical models employed by fellow analysts and the users. The relatively static features of a shared conceptual model form an implicit reference base for communications; and relatively dynamic features form the basis for real-time communications between the analyst and user.

Communication skills for analysts include verbal and writing skills, but they can also encompass the development of new CMs, such as learning a foreign language. Foreign language is of special importance to COMINT and HUMINT intelligence production for obvious reasons. From a general standpoint, language skills are vital to the analyst for understanding the meaning of collected intelligence even after it is interpreted. Writing and speaking skills are essential for the analyst to communicate analytic results to users.

While the basic skills of intelligence analysis are essentially meta-skills that encompass intelligence analysis as a whole, these skills are used in the performance of *task segments*. Task segments are the units that are combined in the performance of analytic tasks. The identification of those task segments during the IMTIA research lead to our understanding of the cognitive processes of analysis and have since proven important in developing training materials for tactical and strategic analysts.

5. THE TASK SEGMENTS OF INTELLIGENCE ANALYSIS

Although intelligence analysis is a complex, challenging process, the cognitive skills used in analysis are not very different from the skills used in solving problems that arise in the analyst's personal environment. The main distinctions are that the cognitive skills of analysis are more systematically structured and require more discipline.

Some of the more important analytic skills were described in Chapter 4. These skills are combined to produce mentally-oriented performances. The IMTIA research identified nine such mentally-oriented performances, or generic task segments, that are required for all intelligence analysis tasks.

These task segments are used in varying combinations for different types of tasks, but they are all required at various times in the performance of intelligence analysis. The analyst should be aware of these task segments as they contribute to the systematic conduct of analysis since each segment has an identifiable contribution to the product of a goal-oriented analytic process. The task segments are represented as a sequence within a rotating wheel (see Figure 1-1) to illustrate the conceptual relationship of each task segment to the analyst's active memory processes. The wheel also suggests a sequential order, but this is not strictly the case. For any specific analytic task, individual task segments may receive more or less attention or may not be performed at all. Some task segments are generally performed more than once in the course of achieving a product goal.

Within the intelligence production cycle, task segments exist between the time interval during which the analyst replaces an existing threat model (see Chapters 6 and 7) with a new threat model. One of the analyst's goals is to create an ideal product that will reduce the user's uncertainty with respect to the threat model. This product requirement cycle is the framework within which the task segments are executed.

The nine basic task segments as identified in the IMTIA studies are as follows:

- Recognizing goals and objectives (always required).
- Establishing baseline (always required).
- Recognizing uncertainties (required as a byproduct of several other task segments).
- Information gathering and interpretation (not always required).
- Hypothesis formulation, including hypothesizing the threat model (not always required).
- Hypothesis testing (not always required).
- Cataloging analytic procedure and results (always required).
- Evaluating results (always required).
- Formulating the output (always required).

The specific details of these task segments differ according to the contents and context of the analytical task to be performed. The relationship of the task segments to the goals, production requirements, users, and work setting contexts was shown in Figure 1-1.

5.1 Recognizing Goals and Objectives

In the military community, goals are usually called objectives. Objectives tend to be more concrete than goals, but in either case, a goal or an objective is the desired end or state toward which effort is directed.

Recognizing a goal or an objective means identifying it, understanding what it really means and the reasons for it. Examples are:

- Recognizing that targets have to be classified by type because weaponeering decisions are based on target type.
- Recognizing the need to know enemy capabilities to be able to predict the enemy's battlefield effectiveness.
- Recognizing that changes in enemy locations may signify a change in intentions.

The overall aim of intelligence analysis is to increase the user's ability to control the situation through an understanding of the enemy threat. Toward this end, regardless of how well the incoming intelligence reports have been prepared, the analyst's specific objectives cannot be met unless the analyst engages in appropriate conceptually-driven processing activities. All analysts must recognize the work-setting context and the user requirements implicit in the mission objective. They must also recognize the higher-level goals inherent in the intelligence community, since they provide the positive values associated with superior analytic performance.

Several concepts and assumptions are relevant to understanding the importance of goals:

- Except perhaps for unconditioned and established conditioned reflexes, all behaviors are implicitly or explicitly impelled by goals.
- Goals are defined as states to be achieved through manipulation of one's environment.
- Unrecognized goals may lead to confusion and detours in achieving those goals.
- When goals are recognized and defined, it is possible to establish the optimum paths to achieve these goals. These paths consist of sub-goals and tasks.
- Effectiveness and task performance is a function of how well goals are defined.

Recognized goals can be specified at different levels. Goal hierarchies can be established that vary over several dimensions, such as:

- Timeframe.
- Analyst's values.
- Importance for individual survival.
- Importance for community survival.

- Concreteness (can they be objectively observed or do they represent abstract ideals?).
- "Repeatability" (are they one-time goals, or do they constantly renew themselves?).
- Conflicts with other goals.

There is a hierarchy of goals, rather than a clear delineation between goals and subgoals. The difference between a goal and a subgoal is one of emphasis and importance and it can change over individuals and over situations. Goal hierarchies can be used to determine the tasks that need to be performed to reach a desired state. Goal hierarchies must be established for each relevant situation, and at least some of the goals within the hierarchy must be important (have affective value) to the individual. Goals have different degrees of importance to individual, but without importance, they cannot be effective in influencing behavior.

The difference between goals and tasks is that, within a specified timeframe, goals tend to be invariant, whereas tasks can change. Goals are things to be achieved; they are states of the world. Tasks are the means for achieving goals and they can change in that, for any given goal, there may be several ways to reach it. Tasks are effective to the extent that they represent means to achieve a goal. Thus, if the end product of a task is unsatisfactory with respect to the goal, one changes the task, not the goal.

Tasks are concrete events that are pre-planned to achieve desired goals or subgoals and performance is the implementation of tasks. Tasks involve changing certain aspects of one's environment so as to reach the goal.

Having clear and well-defined goals facilitates the task of the analyst in several important ways:

- It provides for ordered knowledge usage through active memory since goals are integrated within each conceptual model.
- It allows for optimum sequencing of tasks, subtasks, and task segments.
- It facilitates the development of effective strategies.
- It leads to effective tradeoffs between time resources and other activities.
- It facilitates the resumption of processing after an interruption.
- It provides the basis for evaluation of performance and achievement.
- It makes it possible to evaluate the completion of actions.
- It saves time by focusing the analysis on actual information needs.

The use of goals in learning from complex materials has demonstrated convincingly that learning goals induce the learner to process the material in such a way that performance on test questions (usually sentence completion items) referring to the goal-relevant material is improved. This improvement cannot be explained solely as a redistribution of processing time. The extent of the improvement is somewhat dependent upon the number of goals to be mastered and the ease with which the learner can locate the appropriate material in a text. With a greater number of goals, most subjects take longer to study the material and they are less likely to learn the information relevant to each goal. If all of the data that are relevant to a particular goal are not located together in the information flow, then it will sometimes be the case that only the information contained in the first reference to the goal-relevant data will be thoroughly studied. Therefore, there are some limiting factors in adopting learning goals as learning guides, and the limits are dependent upon both the learner and the materials. The available basic research suggests that each analyst should (a) adopt only a limited number of goals to guide performance and (b) acknowledge potential interpretive biases caused by concentrating too heavily on the initial information pertinent to the goals. Selectivity biases relevant to goal-directed performance are described in Section 5.2.1 and in Section 10.4.

5.2 Shared Goals

In developing shared conceptual models and in identifying relevant goals, it is important to make a connection between the goals that are to be shared and goals that are already important to the individual. For example, according to Godson, there is much competition and (in-house politics) in the intelligence community. The goals of the individual analysts tend to be (selfish) ... analysts are not rewarded for "good analysis" ... there is no positive feedback for having contributed to the shared goal...

Thus, both during training and in the work setting, it is important to consider the following:

Make the goals of analysis personally important to each analyst

Individuals have different goals, but for teamwork to be effective, there should be some shared goals at some level of the hierarchy.

There is an hierarchy of goals, but all of them are important. All tasks have implicit goals associated with them, and most human behavior is guided by goals whether implicitly or explicitly. However, goals must be clearly defined (i.e., they must be spelled out during training) and they must have some "affective value" to be effective in facilitating learning, retention, recall, and performance of a task.

Shared goals promote the development of SCMs. However, analysts need not accept the users' goals as their own to produce the ideal product for the user. Analysts do need to know and understand the users' goal structure, though.

In conclusion, for purposes of training and improvement of analytic performance, it is thus necessary to identify a taxonomy of goals, subgoals, and tasks and to relate this taxonomy to the cognitive skills required to perform the task.

The identification of cognitive skills in Section 8 is the result of combining considerations from the cognitive model with the underlying requirements for analytic tasks.

5.3 Establishing Baseline

Baselines are the initial conditions at the start of the analysis task, along with the knowledge currently available that is relevant to it.

For example, a baseline threat model is a representation of a limited section of the real world that describes currently known events and conditions comprising:

- Enemy forces, behavior, and installations.
- Friendly forces, behavior, and installations.
- Environment (geography, constructions, weather, populations, etc.).

A *baseline* threat model is what is known about those events and conditions at the moment. Establishing a baseline threat model related to friendly objectives consists of:

- Recognizing the events and conditions, described in the threat model, that might affect friendly objectives.
- Filtering out the events and conditions that are unlikely to affect such objectives.
- Integrating the selected events and conditions into a model of the battlefield that is unified and restricted by the objectives.
- Understanding the historical origins of the threat and the events leading to the conflict situation.

5.4 Formulating Hypotheses

Hypothesis formulation is the task whereby plausible visualizations about the real world are created in the context of the mission objective and threat model.

The possible outcomes of the various combinations of potential real-world events that *can* occur must be imagined, in order to:

- Predict those events that are most likely to occur.
- Assess the impact of those events on the task objective(s).

The importance of formulating hypotheses is most obvious in the process of updating the threat model, during which the enemy's probable objective(s) must be discriminated from the universe of his possible courses of action. For the sake of clarity, much of this general description references this task context.

In order to describe how to formulate a hypothesis, it is essential to understand what a hypothesis is and how it is constructed. The relationships that exist between different kinds of events that take place in the world can be classified in terms of their generality and logical role. In following sections, it will become clear that each kind of event is associated with particular types of uncertainty and collection/ interpretation problems.

It is sometimes assumed that intelligence analysis activities are driven mostly by data. This view implies that the objective of reducing battlefield uncertainty is reached by examining all of the relevant information about the battlefield--SIGINT reports, IMINT data, etc. This view assumes that a model can be created of what is actually taking place and of what will take place in the future. In truth, the amount of raw data generated on the modern battlefield is too enormous for a single analyst, or even a team of analysts, to fully process. Even if all the data could be assessed, the number of possibilities that the information implies would also be too vast to evaluate.

In reality, analysts speculate on what possibilities are likely or important, given the baseline model that pertains to the current task. These possibilities, termed *planned outcomes*, are a subset of the universe of possible outcomes. By selecting a likely subset, analysts can concentrate on assessing the likelihood of a reasonable number of cases. This is what is meant by the notion that intelligence analysis is as much "goal-driven" as "data driven." The driving force is the task objective (that is, what is required to reduce uncertainty?), and not the chaotic collection of data and noise that abounds on the battlefield. The data obviously have a major role, but as will be shown, the role involves interpretation and evaluation.

To determine the likelihood of a planned outcome of such a selected subset of data, the pattern of activities that lead up to the event, that is, patterns that *predict* it, must be recognized. Individual activities are sometimes called *objective-oriented processes*. This is because they exist to serve a specific objective, and are dynamic (change over time). Specific objective-oriented processes are related in different ways to a given planned outcome. The ways they are related can often be expressed using *operators* like "AND," "OR," and "NOT." For example, movement of enemy troops toward the FEBA, *OR* movement of materiel toward the FEBA, *AND* massing of enemy troops in echelon may be processes associated with an eminent attack (the planned outcome).

The planned outcome and its related objective-oriented processes are the real world "ingredients" that form the basis of a hypothesis. When converted into the language of logic, the objective-oriented processes are known as *propositions*, and the planned outcome is simply referred to as the *outcome*. A set of propositions that are logically related (through the use of operators), and that imply an outcome, comprise a hypothesis. *The hypothesis states that if the logical relationship among the propositions is satisfied, the outcome will occur.*

In the threat model (see Chapters 6 and 7) for example, a manageable number of possible enemy courses of action must be described. For each of the enemy's potential objectives, a set of propositions are collected that predict the associated objective. The propositions will relate to the enemy forces, the environment, and the mission of the friendly forces. Essentially, the analyst thinks through the enemy's war plan in order to describe those processes that must occur before a given objective is obtained. This thinking process is based on the analyst's knowledge of enemy doctrine and experience, and the collected experience of the intelligence community and results in determining what *evidence* is available or needs to be collected to accept or reject the propositions.

The degree of certainty associated with the evidence, together with the degree of belief in the hypothesis itself (that is, given that the logical relationship between the propositions is satisfied, how likely is it that the outcome is actually implied?) determines how strongly the analyst believes that the outcome will take place. The evidence used to assess the truth of the propositions must be based on real-world data.

These data will be in the form of reports about *potentially observable events*, that is, events that can be observed directly. Such events are "snapshots" in time; they represent the status of an objective-oriented process at a given moment. Multiple snapshots allow the course of a process to be determined, permitting the process to be characterized with greater certainty. An objective-oriented process is basically a logical concept--it is a construct created to relate a hypothetical outcome to observable events. Often based on enemy doctrine, it answers the question "why" particular observed events are taking place.

When applied to confirming or disconfirming propositions, such events are known as ***indicators***. An indicator of troop movement toward the FEBA might be a large number of loaded trucks headed west on a major route. The same indicator might apply to a proposition concerning movement of materiel. Because a single indicator may confirm (or disconfirm) more than one proposition, multiple indicators must often be collected against, in order to assess the truth of a single proposition or to discriminate among several propositions.

Indicators represent the *potentially* observable events that form the basis of collection tasks. These events are not usually observed directly. Instead, analysts rely on the *signatures* of these events to assess the truth of propositions. Signatures are measurable events that take place in the electromagnetic spectrum. This concept must be interpreted broadly; signatures could be SIGINT reports, or the report of a human eye-witness to an event (based, or course, on the light reaching the eye of the witness). The signature is, itself, devoid of meaning. When it is interpreted as an indicator, it's meaning is derived from the mission context and from the threat model.

As can be seen from this description, analysis takes place from the "top down," starting with planned objectives that are potentialities. A model is the created that decomposes a planned objective into its dynamic processes. These processes are then assessed in terms of indicators against which actual data are collected. This permits the testing of a hypothesis that a given outcome will take place (or is planned).

5.5 Recognizing Uncertainties

The hypothesized threat model will always have shortfalls in providing a true representation of the battlefield and the outcome. Analysts must recognize where uncertainties exist in the threat model, evaluate the importance of those uncertainties to the mission, and focus information collection activities on those areas of significance.

As part of the process of recognizing uncertainties, the following questions can be asked:

- Is the threat model adequate?
  - Have all of the plausible options the enemy might include in his war plan been included?
  - Have all relevant aspects of the environment been considered?
  - Are the user's mission objectives known?
- Is there an encompassing list of information items to be provided on the threat model?
- Are the information requirements covered appropriately with a collection plan?

- Are the required resources to gather and interpret collected information available?
- Is there a plan for utilizing new information in the threat model?
- Is there a plan for communicating the threat model information to the user?
- What is the reliability of the collection systems? (Unreliable collection systems create uncertainties about the collected information to be used as evidence in testing hypotheses.)
- Are there differences between past and present collection plans? (The difference between past and present collection plans can indicate uncertainties concerning missing information.)
- What are the effects of the environment on the collection process? (Noise, errors, and communication gaps create uncertainties.)
- How is the information to be used? (Knowing this information reduces uncertainties with respect to the utility of the product.)
- What is the reliability of the analysis? (Unreliable analyses create uncertainties about the validity of interpretation.)

5.6 Gathering and Interpreting Information

Gathering information consists of:

- Assembling already available information.
- Generating requests for information or tasking orders for collection systems.
- Receiving the information from sources via communications means.

Interpreting information consists of:

- Recognizing that information fits known or expected patterns.
- Recognizing that information is different from known or expected patterns.
- Establishing belief about the truth of the information.
- Establishing the utility of the information for accomplishing an objective.
- Integrating the information into the structure of the threat model.

5.7 Testing Hypotheses

Testing hypotheses is the task segment that leads to accepting or rejecting a hypothesis. Hypotheses can also be deferred for future testing based on the outcome of an initial test.

As described earlier, a hypothesis is composed of a set of logically related propositions and an outcome. The propositions represent processes presumed to be predictive of a planned outcome. These processes are assessed by reference to evidence in the form of observable events or indicators. The indicators are essentially "snapshots" of the process and are signified by electromagnetic signatures processed by the collection system.

Although a hypothesis can be rejected on the basis of disconfirming evidence, it is not possible, in formal logic, to "prove" a hypothesis. The most that can be done is to *accept* a hypothesis on the grounds that the evidence supports it better than any rival hypothesis. Generally, the concept of "degree of belief" is a stronger one to apply in hypothesis testing than simple acceptance or rejection.

The degree of belief that can be assigned to a hypothesis depends on the degree to which the evidence supports the propositions and the degree to which the logical combination of the propositions *truly* implies the outcome. Both of these areas involve uncertainties that must be recognized. Consider the following:

- Sensor systems must detect signatures in a noisy atmosphere; there is predictable uncertainty in distinguishing between signals and noise.
- You cannot be absolutely certain that the signatures imply an indicator.
- You cannot be absolutely certain that the indicator implies the proposition.
- You cannot be absolutely certain that the propositions imply the outcome.

The element of deception enters into the hypothesis testing process by producing false or misleading signatures and indicators. In preparation for a course of action, the enemy can select options that are not optimum, but will suffice for the planned action. The indicator will therefore point most convincingly to an erroneous hypothesis, while the actual outcome appears to be less strongly supported. Analysts may be misled into accepting a hypothesis for which the indicators support the optimum objective-oriented processes.

Two concepts are of particular importance in dealing with uncertainty in the testing of hypotheses. The first is *reliability*. This term normally refers to the degree of repeatability of a measurement. (That is, given several repetitions of the same signature, how consistently would a collection system report the same measurements?) Reliability can also be applied to logical propositions. (That is, how often would confirmation of the propositions of a hypothesis be followed by the expected outcome?)

The second concept is *validity*. A signature is valid if its meaning is correctly assessed, that is, if it is in fact associated with the designated indicator. An indicator is valid if it truly indicates the proposition with which it is associated.

Improper judgment of these factors can result in two types of error. The first is the probability of falsely rejecting a hypothesis. The second is the probability that a hypothesis has been falsely accepted (a "false alarm"). Since analysts usually consider a set of hypotheses and attempt to reduce it to either one or a smaller set (depending on the user's requirements), both of these errors are usually committed together.

In addition to carefully assessing the reliability and validity of the evidence that supports or disconfirms hypotheses, it is necessary to pay special attention to how critical a piece of evidence is, how vulnerable to deception it is, and how well it discriminates among the competing hypotheses. Not all evidence need be applied to the test with equal weight. Evidence that does not discriminate between hypotheses is not useful. More reliable evidence can be weighted more heavily. Evidence that is subject to deception must be applied cautiously, and with sensitivity to evidence that might, itself, permit a test of the hypothesis that deception is being practiced.

If a decision cannot be made on the basis of the available evidence (that is, if the degree of belief among competing hypotheses is close), final evaluation of the evidence may be deferred until more data become available. Before making this decision, however, the user's information requirements and the time frame of the user's decisions must be carefully considered.

5.8 Evaluating Results

Analysis is an [illegible] that could continue indefinitely. Evaluating results is a task segment necessary for knowing how long the analytic process should be pursued and for evaluating productivity. Knowing when to stop can be determined by asking the following questions:

- Have all mission information requirements been identified?
- Is there an adequate collection plan?
- Has the collection plan been executed properly?
- Has the threat model been updated?
- Has the product been prepared?
- Has the product been communicated?

Each question reflects an iterative task of reducing uncertainties. It is unlikely that all uncertainties will ever be reduced to a point of having "ground truth." Since results will never be perfect, the question of "When am I done?" is determined by when time and information resources are exhausted.

Analysts must learn to prioritize the order in which tasks are accomplished to maximize the effectiveness of the resources. In all cases, this ordering is based on judging how accomplishing the various tasks relates to reducing the risk to the mission.

5.9 Formulating Output

Output is the intelligence product. Formulating output means to "tailor" it for a particular user's benefit.

To insure that the output is adapted to the user's needs, analysts should ask themselves:

- Do I know and understand the user's objectives?
- What are the constraints under which the user is currently working?
- Do I know enough about the way the user thinks so that I can communicate the product appropriately?

5.10 Cataloging

Cataloging is the task segment used in recording significant information about the analytic process itself and in transferring that information to appropriate users and/or to storage. Cataloging requires extreme discipline and a systematic approach. The recorded information that results from cataloging is the primary basis for communication within the intelligence organization and with intelligence users. It also permits retrieval of information for use in future analyses.

In determining what items to catalog, analysts should ask questions such as:

- How crucial is it to remember this information?
- Can I use this information again at a later time when I might have difficulty remembering it?
- Is someone else going to benefit from the recording of this information?
- Is this information necessary to justify the intelligence product?
- How frequently is this item refreshed or replaced by new collection activities?
- How important are trends or variability in this item?
- Might I have to reinterpret this information at a later time?

Any of the tasks performed in analysis may require cataloging significant items for later use.

6. THE CONCEPT OF THREAT

Many aspects of intelligence analysis are due to the fact that "Threat" is the target of analysis. Threat is a complex concept that involves context (threatener, recipient, time, geographic location); communication of threat, perception of threat (by analyst, by user); and control of threat (physical and cognitive). *Threat is an anticipated danger to a National Interest in a particular contingency from a foreign force.*

Threat perceptions and the reactions to the various factors of threat are individualistic, but threat must be treated in a standardized manner because of the complexity of the various factors that underlie threat perception and the potential seriousness of threats against the national interests.

Analysts, among each other and with the users of intelligence, need to develop the same understanding of the battlefield context. The purpose of modeling the threat is to standardize these perceptions; the purpose of verbalizing how people think, react, analyze, and interpret threat is to lay the groundwork for developing a shared conceptual model of threat.

6.1 Perception of Threat

The various aspects associated with the perception of threat have an important influence on how threat is controlled, both by the analyst and the user. Although the analyst's perception of threat is frequently mitigated by factors extraneous to the dictates of good analysis, such as national policy, organizational characteristics, user idiosyncrasies, or simply "conventional wisdom" (a mild form of prejudice, according to Codevilla, 1980), using a common threat model can do much to alleviate some of these extraneous problems.

The five aspects most relevant to the perception of threat are described below.

6.1.1 ASSESSING THREAT

Analysts use numerous specific analytical skills in assessing threat. Threat is a multi-dimensional situation that involves many uncertainties and many contingencies. In assessing threat, the analyst must have a good understanding of, knowledge of, and ability to use problem structuring and decision making techniques, as well as techniques for evaluating and dealing with uncertainty. These techniques must be combined with a thorough knowledge of the environment and of the available resources.

6.1.2 THREAT CREDIBILITY

The credibility of a threat is a function of intention and capability on the part of the threatener. The credibility of an intention is difficult to evaluate since it involves anticipating how the enemy thinks. An enemy force's capability, however, can be evaluated in the more concrete terms of weapon performance and lethality, force size, disposition of forces, combat effectiveness, and other factors. Predicting the capability of a future force involves additional factors such as estimates of the nation's manpower and industrial base, technology, training capabilities, supply lines, and alliances.

6.1.3 COMMUNICATING THREAT

To communicate threat, there must be a shared conceptual model of the threat between the analyst and the user. The importance of shared conceptual models in communication was discussed in Chapter 3. Accurate communication about the threat is possibly the most important aspect of the analyst-user relationship, since an accurate understanding of threat is basic to making correct decisions concerning the battlefield situation. Training the analyst to understand how the users of intelligence think, and what their requirements are, is a prerequisite to the establishment of a common model of threat between analyst and user.

6.1.4 REACTION TO THREAT

The user's reaction to the threat will depend on perception of danger and the degree of control over the situation. The level of danger represented by the threat is the potential for harm, physical loss, or injury, if the threat is carried out. The danger represented by the enemy is the potential loss to the friendly forces in terms of personnel, materiel, or other national interests.

Danger is differentiated from risk. Risks are "taken" when danger is known to exist. Thus, risk is a voluntary exposure to danger, however unavoidable it might be given the circumstances. In combat, there is risk in not preparing counters to an enemy's threat, whether or not that threat has credibility. Risk is increased as a function of potential danger and decreased when the enemy threat credibility is lessened.

Risk taking is a psychological characteristic that depends on how people perceive threat and react to it. Milburn and Watman (1981) provide a view of threat perception that has implications for understanding peoples' reactions to threat. Milburn and Watman's model is shown in Figure 6-1; it proposes that behavioral responses to threat perception are a joint function of the amount of danger present and the amount of available control over the situation.

The model further suggests that, regardless of the amount of danger involved, an increase in the amount of control available will have a positive behavioral outcome (sense of comfort or challenge). One of the analyst's most important goals, therefore, is to provide an increase in the user's ability to control the situation. An increase in the user's ability to control the situation is automatically associated with a decrease in uncertainty, thereby fulfilling one of the goals of intelligence analysis.

The user's ability to control the situation is very much dependent on the analytic product. The shared threat model is a tool used by both analysts and users to ensure as complete and accurate a representation of the threat situation as possible, tailored to the particular mission requirement.

A good threat model can provide both cognitive and physical control. Having knowledge of all the relevant elements (and the relationship between the elements) associated with a mission, generates the necessary understanding of the availability

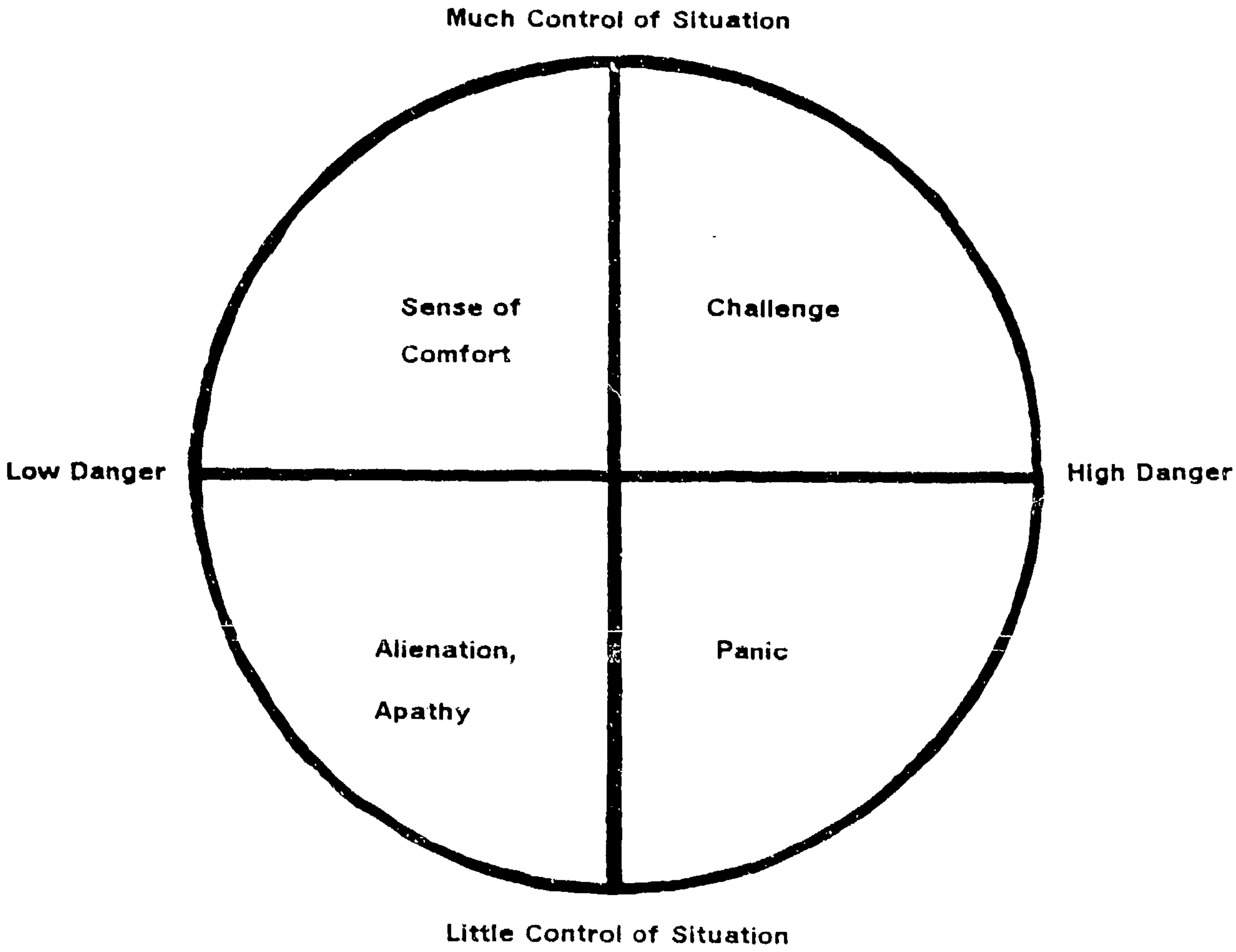

Figure 6-1: Behavioral Response to Threat Perception as a Function of Danger and Control.

and potential for physical control. On the other hand, the users' knowledge of having a shared threat model with the intelligence analysts, generates the best possible cognitive control.

6.1.5 *EVALUATING THREAT*

The evaluation of threat as the target of analysis must always be performed within a particular context and must include the use of a "Threat Model". Threat modeling requires an understanding of both cognitive and physical factors that impact on analysis. Cognitive factors are those that determine how the analyst or user will react to their perception of threat, as discussed by Milburn and Watman (1981). Physical factors are those that concern the dimensions of the battlefield. Both the cognitive and the physical factors underlying perception of threat depend on the amount of uncertainty present in the threat situation.

Uncertainty plays a key role in the evaluation of threat. First, there is the uncertainty about the enemy intentions concerning the real objective of the threat and the enemy's options for achieving that objective. Second, there is uncertainty in evaluating the capabilities of the enemy force to carry out a threat. Third, there is uncertainty in the five battlefield risk factors, namely, lethality, warning time, enemy options, friendly options, and environmental conditions. Fourth, there is uncertainty that the method of response will produce a desirable outcome.

These uncertainties are clearly identified in the threat model, thereby minimizing the lack of control that arises from having uncertainties about uncertainties.

In developing a cognitive model of the intelligence analyst, and in identifying the skills required to optimize analytic performance, the IMTIA research laid the groundwork for identifying the various aspects and elements of the threat model, and for specifying means to develop it. The elements of the threat model are described in the following section.

6.2 Threat Modeling

The intelligence analyst engages in a complex mental activity that is described as *Threat Modeling.*

Modeling is a fundamental intellectual process of intelligence analysis. The frame of reference of the modeling activity is the battlefield. The objective of the modeling activity is to provide representations of battlefield threats and opportunities for control so that information that reduces outcome uncertainties can be provided to commanders.

The intelligence analyst is only one of the battlefield modelers supporting the combat force commander. Other analysts provide models of maneuver operations, logistics, combat, and support missions. Differential interpretations must be made by each of the operational elements of a combat force. The intelligence analyst focuses on threat posed by enemy forces but integrates the meaning of threat in terms of the significance to specific national interests or the conduct of specific friendly force operations.

6.3 Features of the Threat Model

Regardless of the interpretation of the threat model, its basic features are common to all users. These basic features comprise three different perspectives, each having numerous associated elements that interact across perspectives.

The three perspectives of the threat model are called RED, WHITE, and BLUE, referring respectively to the enemy, the environment, and the friendly forces.

6.3.1 *THE WHITE PERSPECTIVE*

The initial step in threat modeling is always the development of the WHITE framework in the two dimensions of space and time. It is the white framework that anchors the threat model to the real world.

Developing the geographic framework of the battlefield can be as simple as plotting the battlefield on a map. The map is a model of the real world. The topographic map contains a wealth of information about the battlefield environment, including descriptions of terrain, roads, population centers, etc. When highly detailed military maps are available, they contain much of the information that contributes to the threat model. An important task of strategic analysts is the development of white frameworks in areas of anticipated threat for later use by tactical analysts.

Time, as the second dimension of the white framework, is treated as a sequence of time period snapshots (or windows) within which events occur. Threat model time can be compressed to bring events closer together or expanded to make individual events more distinguishable. Time windows can be overlaid on each other in order to see patterns of events or to distinguish changes.

One of the snapshots in the threat model sequence must represent the current time frame. A sequence of snapshots allows courses of action to be followed, from the current timeframe to the eventual outcome of the battle. Each snapshot can be thought of as an overlay of information over the battlefield geography.

Future automated data-processing capabilities might provide an interactive computer graphics terminal for creating the threat model, carrying static information from one snapshot to the next, and integrating new information into the model.

6.3.2 *THINKING WHITE*

Filling in the time and space framework of the threat model is the process of thinking WHITE. Thinking white creates an organizational structure for the threat model and identifies the impact of the battlefield environment on RED and BLUE. The time framework provides a way to follow the dynamics of the battlefield and to discriminate events and activity levels in the spatial framework. By spreading the threat model information out over a time as well as a spatial framework, individual events and patterns can be discriminated.

Time dependencies can be shown in the threat model by labeling information with date-time tags or by placing information in a series of overlays organized by time-window boundaries.

Thinking white is always done in terms of a geographic framework. The boundaries for thinking white depend on the specific mission objective and could take the form of:

- World region.
- Country.
- Local area.
- Township.
- Military district.
- Area of interest.
- Area of influence.
- Zone.
- Specific map coordinates.

The geographic framework can be either 3-dimensional or 2-dimensional, or represented by a point reference such as a name or area identifier.

Thinking white also involves exploiting the knowledge of the battlefield environment. Environmental knowledge used in white thinking includes:

- Terrain.
- Weather.
- Population.
- Economy.
- Energy and natural resources.
- Academia and technology.
- Transportation.
- Communications.
- Political and military organizations.

Much of this information is available from intelligence and non-intelligence sources. and can be referenced to the geographic framework.

The focus of white thinking concerns the three major areas of:

- Lines of communication.
- Battlefield climatic conditions.
- Uncertainty.

The following subsections discuss the specific white thinking techniques that address these areas.

6.3.2.1 Lines of Communication

Because the information volume associated with the white element can be massive, ways of simplifying the access to this information are needed. A principal technique for linking environmental information together within the white framework is the notion of "lines of communication." For example:

- Population centers are linked by roads, railways, waterways, airline routes, and communications systems.
- Elements of an organization are linked by lines of authority and physical communication networks.
- Energy producers are linked to consumers through power distribution systems.
- Ethnic groups are linked through culture, language, economic, and political lines.
- Technology users are linked with the academic and research organizations that produce that technology.
- Military units use doctrine, operations, and tactics that are passed along through training and command lines. Units are sustained through transportation lines.

6.3.2.2 Battlefield Climatic Conditions

White thinking is used when considering climatic effects on the battlefield courses of action. Climate is used in a general sense to refer to any form of environmental state that impacts on battlefield activities. Battlefield climatic conditions can include:

- Weather conditions (effects on personnel, operations, equipment, collection systems, transportation, supply expenditures, etc.).
- Terrain (foliage for cover and concealment, communications effects, cross-country trafficability, etc.).
- Electromagnetic propagation conditions (noise, interference, crowding, blocking, etc.).
- Social climate of local population (reaction to enemy or friendly forces, likelihood of partisan forces, sabotage, etc.).
- Economic climate (commercial, industrial resources of area, economic stability of local area).
- Political climate (political organization, stability, cohesiveness, goals, etc.).
- Military climate (readiness, professionalism, ideology, motivation, etc.).
- International climate (alliances, treaties, mutual interests that might involve intervention, disruption, or support from other nations).

Some factors, such as international climate, are treated primarily at the strategic level, but the tactical intelligence officer must understand their effects on the battlefield conditions. In pre-hostility situations, these factors can be more significant because they will bear on the immediacy of the threat and possible escalation of the danger in the threat situation.

6.3.2.3 *Uncertainty in White Thinking*

Uncertainties in white information can have critical impacts on the outcome of the battle or on strategic projections. Locations of strategic targets, even if accurately plotted can cause problems if the map is inaccurate. The time period of interest can impact the accuracy of predictions. If the time period of interest is very extended, predictions of weather conditions are likely to be based on general weather trends or historical averages and will therefore be inaccurate.

For a large, generally defined battlefield, analysts may have to rely on general, possibly imprecise information. Frequently, only statistical information (such as demographics) are available to describe the population and economic climate of the country area. It is important to identify what environmental conditions will be significant to specific missions so that collection resources can be tasked to provide greater detail and accuracy.

6.3.3 *THE RED PERSPECTIVE*

The RED perspective of the threat model must be anchored in the real world where enemy forces are implementing the political and military policies of the foreign nations that generate those policies. The enemy combat force is an extension of political policies that are the source of the conflict that creates the battlefield situation.

The initial step in introducing the red element to the threat model is to plot the locations and linkages of the political, military, and combat organizations within the geographic framework of the battlefield. The highest echelon of enemy organizations plotted depends on the echelon of interest of the friendly force commander. For example, the strategic-level threat model encompasses all aspects of the civilian and military force structure, whereas a division-level threat model might show only the locations of the red forces up to the army level.

The organization of the red elements follows some form of hierarchical subordination structure connected by lines of communication. The lines of communication show the relationship between units for command, control, and coordination. These lines of communication can be overlaid on the geographic structure and related to physical communication paths such as roads, transmission lines, or electromagnetic transmission paths.

Within an actual combat environment, the locations of combat units vary dynamically. Correspondingly, the positions of units must be periodically updated within the threat model.

6.3.4 *THINKING RED*

To think RED is to visualize the enemy's war plans. The red war plan provides an expected pattern of events that helps in avoiding surprise. Departures from the red war plan can be recognized as unusual activities that may signify a need for additional collection, warnings to the friendly force, or revisions to the threat model. The red war plans define:

- Why the enemy will fight.
- Where the enemy will fight.
- When the enemy will fight.
- What force structure the enemy will use.
- What objectives the enemy hopes to achieve.
- What time table the enemy has for accomplishing objectives.
- What possible options the enemy will use.
- What courses of action will be followed to achieve objectives.
- What operations/tactics the enemy will use in pursuing courses of action.
- How the enemy views his strengths.
- How the enemy views his weaknesses.
- How the enemy views the strengths and weaknesses of blue forces.

A large part of the strategic intelligence products of Army and other national intelligence organizations are concerned with answering these questions.

Thinking from inside the enemy's war plans is a powerful tool for reducing the number of potential battlefield options that are considered in preparing an estimate. Every hypothetical option can be tested by asking how it fits into the enemy's overall war plans, and then eliminated, if the option does not fit.

There are three techniques for filling out the red warplan:

- Structuring the war plan using enemy doctrine.
- Exploiting intelligence sources to fill in details.
- Using analogies to fill in missing information.

Because the enemy is guided by their doctrine, strategy, operational art, and tactics, thinking red must begin with enemy doctrine.

6.3.4.1 Enemy Doctrine

Doctrine is a term that is typically used to refer to the fundamental principles that guide the actions of a military force. However, from the enemy perspective, the term doctrine has a specific meaning that has no counterpart in our armed forces. Enemy doctrine is an officially accepted system of views concerning the nature of war, methods for its conduct, and preparation of the country and army for war. At a minimum, enemy doctrine answers the questions:

- Who will be faced in the war?
- What will be the nature, goals, and missions in the war?
- What armed forces will be needed in such a war?

- In what direction should military development be carried out?
- How will preparations for war be implemented?
- What methods will be needed to wage war?

Doctrine originates at the highest political level, and the formulation of doctrine is concerned with more than military factors. Enemy military doctrine represents the union of politics and science in support of national objectives. Enemy doctrine is concerned with the future war and therefore precedes the development of actual military capabilities. Because doctrine may precede military capabilities by as much as several years, it can be exploited as a framework for the threat model in a peacetime environment. Understanding enemy doctrine is fundamental to strategic intelligence.

Military strategy is the implementation of enemy doctrine. Military strategy is concerned with the preparation and use of forces in war. The enemy combat situation is guided by military strategy, not doctrine.

Operational art is concerned with preparing for and conducting joint and independent operations. Operational art determines tactical missions and the role and place of units and formations in achieving operational goals.

Tactics are concerned with the fundamentals of preparing for and conducting combat operations by units and formations. The meaning of tactics, from the enemy perspective, is similar to our own.

The red war plan evolves in a top-down manner from doctrine. Without a broad, in-depth knowledge of enemy doctrine, an analyst will not have an adequate foundation for developing the red perspective of the threat model.

6.3.4.2 Intelligence Sources

Intelligence sources can fill in much of the enemy war plan items. Strategic intelligence sources provide studies of enemy doctrine, strategy, weapon system characteristics, and general information on the battlefield environment. Strategic analyses of exercises can supply details on how the enemy trains and operates. Much of the procedural aspects of training will carry over into battlefield operations and tactics.

Intelligence is continually produced in peacetime and in wartime on enemy unit composition, communications, electronic warfare capabilities, and characteristics and performance of weapon systems. By knowing the capabilities of combat systems, it is possible to predict how the enemy might plan to use such a system in the battlefield. This technique is used to fill in the threat model from the "bottom up."

6.3.4.3 Using Analogies

Analysts use analogies to fill in missing information. For example, if they have no information concerning some aspect of a red motorized unit, they may assume that it has some commonalities with a Blue mechanized unit and then draw an analogy from this assumption to fill in the missing information. This technique is referred to as mirror imaging.

Mirror imaging can be a powerful technique for filling in missing information when no other source exists. However, it is always possible that unknown factors will invalidate the mirror-imaging assumptions. For instance, assumptions that Soviet doctrine and tactics will transfer intact to a Warsaw Pact unit is generally valid because there is an environmental similarity between the two forces. However, the same assumption cannot be made about the use of those same tactics in a Southwest Asian country because the environment and the culture of the forces are so different.

A common pitfall of inexperienced analysts is to assume that the enemy's rationale is a mirror image of their own thinking. This kind of error can lead to serious consequences for the friendly force if decisions are based on that rationale. It is for this reason that analysts must always identify their assumptions and sources of information when developing the red war plan. The need for mirror-imaging is reduced in proportion to the analyst's background knowledge concerning the ideology, culture, language, doctrine, training, and history of the enemy. The analyst's goal is to place him- or herself in the role of the enemy and, in fact, to think red.

6.3.5 *THE BLUE PERSPECTIVE*

The threat model takes on its full meaning when the BLUE perspective is introduced along with WHITE and RED. The targets of the red threat are BLUE elements. The components of the friendly force are also blue elements. The blue elements are introduced into the threat model by plotting the location of strategic targets in the white framework.

6.3.6 *THINKING BLUE*

Blue thinking is founded on the principles of war. These principles form the operational framework for military actions. The principles of war are not rules; rather, when understood and applied, the principles should stimulate thought and enhance flexibility of action. From U.S. Army Field Manual 100-1, the nine principles are:

- Objective--Every military operation should be directed toward a clearly defined, decisive, and attainable objective.
- Offensive--Seize, retain, and exploit the initiative.
- Mass--Concentrate combat power at the decisive place and time.
- Economy of Force--Allocate minimum essential combat power to secondary efforts.
- Maneuver--Place the enemy in a position of disadvantage through the flexible application of combat power.
- Unity of Command--For every objective, there should be unity of effort under one responsible commander.
- Security--Never permit the enemy to acquire an unexpected advantage.
- Surprise--Strike the enemy at a time and/or place and in a manner for which he is unprepared.

- Simplicity--Prepare clear, uncomplicated plans and clear, concise orders to insure thorough understanding.

The principles of war define a structure for blue thinking. Each principle defines a potential use of threat model information.

Thinking blue requires analysts to place themselves in the role of the intelligence user. This often means a total change of perspective from developing what the enemy is doing, and thinking instead in terms of blue force actions. Changing to the blue perspective means that analysts must think in the same time context, level of detail, and terminology of the person using the threat model information.

Thinking blue involves the following four combinations of perspectives:

- RED attacks BLUE.

  Thinking BLUE in the defense requires looking at the RED war plan from the perspective of how the friendly force is a target. The information drawn from the threat model is from the perspective of warnings and level of danger from RED attack.

- BLUE attacks RED.

  Thinking BLUE in the offense requires looking at the RED war plan in terms of weaknesses, vulnerabilities, strengths, and critical points in courses of action.

- WHITE affects RED.

  Thinking of how WHITE affects RED requires looking at environmental conditions that contribute to or detract from the desirability of red options. These options are viewed from the BLUE perspective of choosing the timing or locations of conflicts.

- WHITE affects BLUE.

  Thinking blue from the perspective of environmental conditions means looking at the impact on the effectiveness of blue operations under those conditions.

Thinking blue requires filling in the threat model in terms of different types of information, such as:

- What options are being considered by the friendly force?
- Is a blue unit in danger of attack? Is a warning needed?
- Is there a possibility of a new option in the red war plan? Should this option be known to avoid surprise?
- Are there technological breakthroughs that might change existing forecasts?
- Are there new political or military personalities that may alter the red war plan?
- Is there a significant change in the mass or concentration of red forces? What information is needed by the blue force to execute a countering change?
- What does the enemy know about the blue war plan? What can be done to cover or deceive the enemy about this plan?

- What are the critical areas of uncertainty? What collection assets can be directed at these areas?
- What information is needed to carry out the missions in the operational plan?

By rehearsing the types of questions that the intelligence user might ask, it is possible to anticipate the types of information needed to fill in the threat model.

Because the threat model is dynamic, it is never completed. However, it is possible to "freeze" it at any given time period to use for predictive purposes. This is done by selecting the appropriate time window for closer examination. The act of developing the threat model as well as a particular time window, serves many needs.

6.4 Uses of the Threat Model

Threat modeling is the act of creating a mental picture of the battlefield in order to predict the outcome of combat missions. A threat model of the battlefield contains more information than would be possible by simply accumulating facts from available information sources and in this capacity, it serves many different needs:

6.4.1 THE NEED FOR PIECING INFORMATION TOGETHER

The threat model is a mental framework used to piece information together, to aid in remembering, to identify missing information, to speculate and predict, and to do problem solving for finding information.

In piecing information together, the threat model must address the following issues if it is to effectively portray the battlefield knowledge:

- Illustrate current knowledge of the enemy forces, including their strength/ capabilities, disposition, combat effectiveness, and readiness state.
- Depict strategy of enemy forces, including their intentions, commitment of forces, doctrine and ideology, employment of operational techniques, equipment and tactics, and intermediate objectives and timing of events.
- Identify areas of uncertainty and assumptions used to fill-in or compensate for shortfalls.
- Provide logic for indicators that can be used to predict, warn, and monitor the execution of a threat against friendly forces.
- Qualify the credibility of the enemy force to carry out a threat under contingencies of environmental factors (weather, political, economic), enemy's level of uncertainty of success, and friendly force options for intervention and response.
- Provide breadth of scope and levels of detail necessary to see opportunities for controlling threat and achieving desirable outcomes for friendly forces. The types of information produced by the model should ensure both understanding and detail necessary for operation of friendly forces.

6.4.2 *THE NEED FOR MEASUREMENTS*

The threat model provides information that may not be otherwise available. Most importantly, the threat model provides ways to make measurements that quantify the danger and risk present in the threat situation. Changes in the model over time are used to measure trends, identify patterns, and detect changes in activity levels.

6.4.3 *THE NEED FOR COMMUNICATING AND EXTERNALIZING INFORMATION*

Because the information contained in the threat model has been systematically represented, it is possible to communicate and externalize the information contained in the model. This is an extremely important aspect of the threat model, since analysts must communicate their products to the intelligence user in a timely, accurate, and appropriate (tailored for the user) manner.

Being able to externalize the threat model information implies a translation of the analyst's mental image of the battlefield into language, symbols, and graphics. This aspect is vital since the amount of information represented by the threat model is well beyond the limits of the human memory.

6.4.4 *THE NEED FOR DIVIDING THE WORKLOAD*

The threat model provides an organizational structure for dividing up the analytical work load. Individual analysts can share in the building and maintaining of the information in the model, and can also share in the benefits of the information provided by the model.

6.4.5 *THE NEED FOR A COLLECTIVE MEMORY*

The threat model of modern warfare options is so complex and extensive in its scope and coverage of massive volumes of data that many analysts are required to create and maintain the model. No one analyst could hope to memorize the entire scope of the model information. The threat model thus becomes a form of collective memory between cooperating analysts and the operations personnel that the model supports.

The collective analytical team is created by exploiting specialized knowledge in:

- country area knowledge for creating environmental framework
- technical knowledge for interpretation of indicators from signal, imagery, and human collection resources
- geographic partitioning for distributing work load
- technical specialization in interpretation of data with high levels of uncertainty
- technical specialization in modeling of physical systems
- operational exploitation of model information in user areas.

6.4.6 *THE NEED TO EXTERNALIZE THE THREAT MODEL*

The threat model, because it cannot be easily dealt with in internal memory, must be encoded for communication and external storage. The most commonly recognized forms are seen in:

- Threat estimates.
- Situation displays over map backgrounds.
- Order of battle databases.

These forms are only partial threat models but represent consensus views of an analytical team. Also representing part of the externalized threat model because they represent community knowledge are:

- Documented doctrine and tactics of opposing forces.
- Documented characteristics and capabilities of weapon systems.
- Maps.
- Intelligence, military, and state department message traffic.
- Previous intelligence products.
- Intelligence lore transmitted through oral tradition.
- Technical knowledge from non-intelligence sources.
- Ethno-graphic knowledge available from non-intelligence sources.
- Current events knowledge from open sources (newspapers, periodicals, publications, wire services, broadcasts).

These secondary knowledge sources are effective as a component of the threat model in direct proportion to their circulation and accessibility to analysts.

Because the volume of externalized threat model data can be enormous, analysts have intuitively devised techniques for minimizing memory requirements and improving accessibility, thereby achieving a form of "cognitive economy." Examples of cognitive economy mechanisms include:

- Geographic plotting of time stamped messages, indicators, and episodes for filtering, correlation, and activity level evaluation.
- Environmental surrogate models (such as LOC) for simplified environmental focus.
- Predictive system templating with pre-processed data components to depict composition, behavior, characteristics of entities.
- Predictive event templating to depict event occurrences, timing, signature, and relationships to indicators.
- Symbols and iconics to represent standard entities, events, situations (includes military symbology, map topographic symbology, unit names and designators, etc.).

Cognitive economy is further achieved in a more general way. Specifying that a threat model is necessary, or that analysts have to be trained in how to develop and use a threat model, is not enough. To be truly useful, it is necessary to establish criteria for evaluating training and analytic performance. The next chapter discusses issues for evaluating training and describes techniques for developing the ideal threat model.

7. EVALUATING INTELLIGENCE TRAINING AND PERFORMANCE

7.1 The Ideal Analyst

The characteristics of an intelligence system can be evaluated by comparing the properties of an actual system to those of an ideal system. The requirements of an ideal production system may pose insurmountable demands the limitations of human cognitive processing, so that actual performance may never approximate the ideal. However, a judicious extraction of concepts from an ideal production system, in conjunction with an understanding of the relevant cognitive structures and processes, can lead to the identification of training guidelines and criteria for evaluating analytic performance.

The cognitive model of intelligence analysis (described in Chapters 2 through 5) was derived from production requirements, data from on-the-job interviews with intelligence analysts, analysis of the current cognitive literature, and analysis of the cognitive performance requirements of intelligence analysts. In what follows, we examine the components of the ideal cognitive performance model and the ways in which actual performance compares to the ideal.

To illustrate what the cognitive model can and should accomplish, an approach is proposed consisting of the ideal analyst, the ideal performance, and the ideal product, as represented in Figure 7-1. In this conception, ideal states are postulated and compared to actual states; then the sources of the differences between the two are identified. The sources include human biases and various types of errors as well as various mechanisms that are typically used by humans, such as filtering and selection of information, stereotyping, and assimilation. These are influences that have an impact on one or all of the constructs shown in Figure 7-1.

A goal is to identify techniques or mechanisms that can compensate for sub-optimal performance in an actual operational environment. The steps necessary to identify the ideal analyst performance are:

- Identify the task segments.
- Identify the cognitive skills required for each task segment.
- Make a profile of the cognitive skills for each task segment.
- Relate the cognitive skills to the structures and processes of the cognitive model.
- Identify the attributes associated with each cognitive structure and each process.
- Assign optimum values to the attributes identified above.

To identify compensatory approaches for sub-optimal performance, the following steps are taken:

- Identify potential error sources that impact on each cognitive structure and process and evaluate their significance within the definitional framework of the ideal performance.

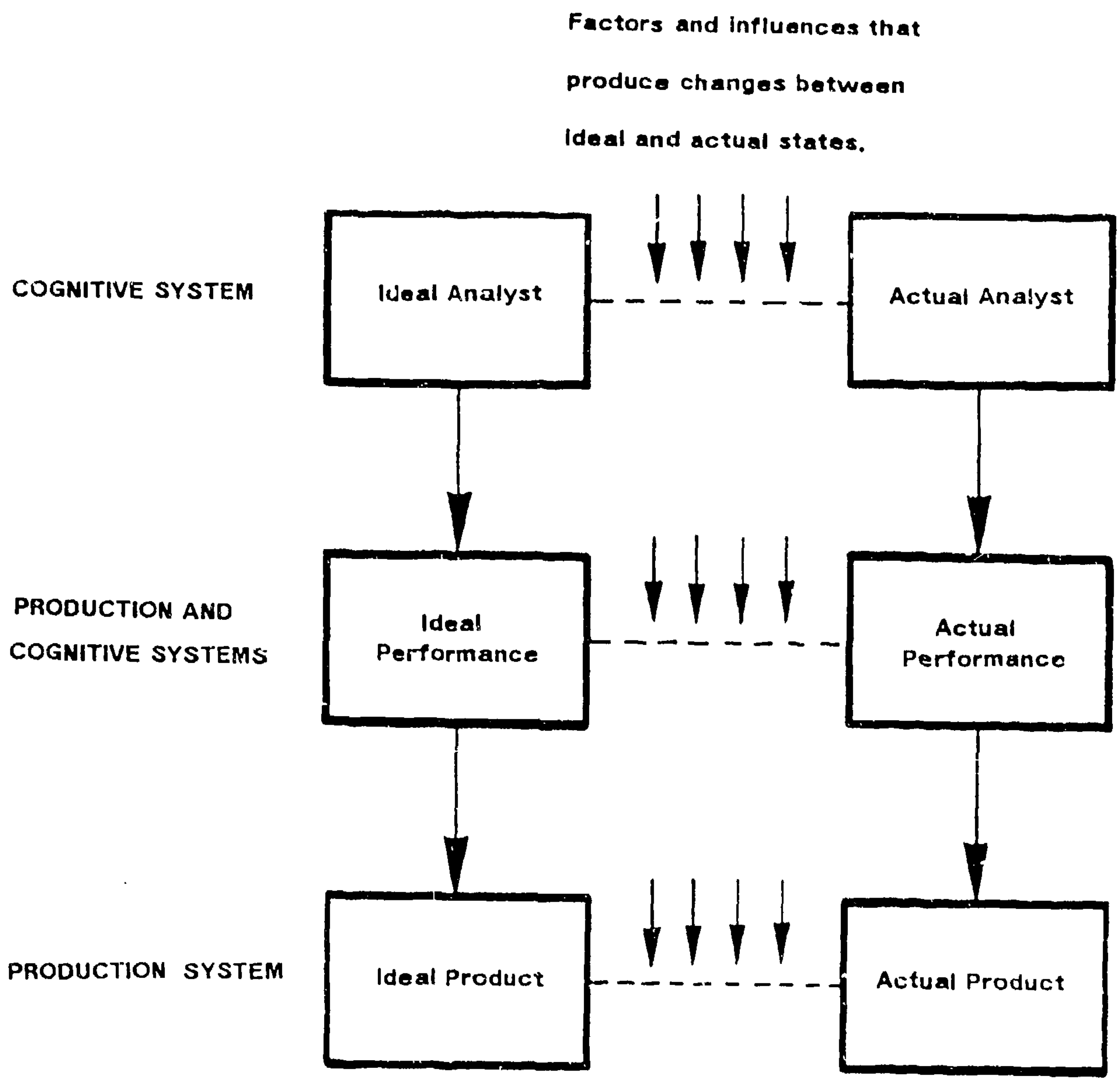

Figure 7-1: Approach for Evaluating Intelligence Performance and Product.

- Select a compensation mechanism or technique that can minimize the deviations between the ideal and the actual performance models.

Task segments are defined in terms of observable behavioral outputs that are required to perform a particular task, and/or achieve a specific goal. Task segments, then, are aspects of the production system that are an important consideration within the performance model. To understand the relationship between the production model and the performance model, the cognitive skills needed to perform each of the task segments have to be identified, as shown in Figure 7-2. For each task segment there are a number of associated skills, although not all skills are equally relevant or important. It is necessary, therefore, to make a profile of the required cognitive skills for each task segment, in which the profile reflects the relative importance of each skill in performing tha particular task segment. The relative importance can then be represented as a value on an arbitrarily defined scale, for which the values are derived from the interview data interpreted through an understanding of the cognitive performance model.

Cognitive skills are very broadly defined in this context. They refer to the use of procedural and analytical skills, as well as to the basic capacity of memory, the capacity for attention and for dealing with stress. They can also include the effects of physiological, personality, and emotional variables, since all of these have a potential bearing on the way task segments are executed.

Figure 7-2 also shows how each separate cognitive skill has an identified relationship to the various structures and processes of the cognitive model. As an example, the cognitive skills, structures, and processes involved in performing the task segment "Hypothesis Testing", involve the following steps:

- Selection of attributes of the hypothesis.
- Translation of the attributes into specific aspects of the information.
- Test against the most closely matched template within the conceptual model.
- Evaluate the outcome of the test. It is at this point that errors and biases may affect performance. In the case of hypothesis testing, the most prominent bias is the tendency to seek confirmatory evidence, and to ignore disconfirming evidence.
- If the outcome is unsatisfactory, the steps above are repeated. If the outcome is satisfactory, the task segment is completed.
- The iterative process may continue over a period of time, or it may direct the search for new information which could lead to the generation of new hypotheses.
- In directing the search for new information, the iterative process could be led along irrelevant or erroneous paths. This is another point in the process where the confirmatory bias could manifest itself.

Cognitive skills form the link between the task segments identified within the production system and the structures and processes that make up the cognitive model. These skills can be divided into categories that are associated with the structures and processes of the cognitive model, as follows:

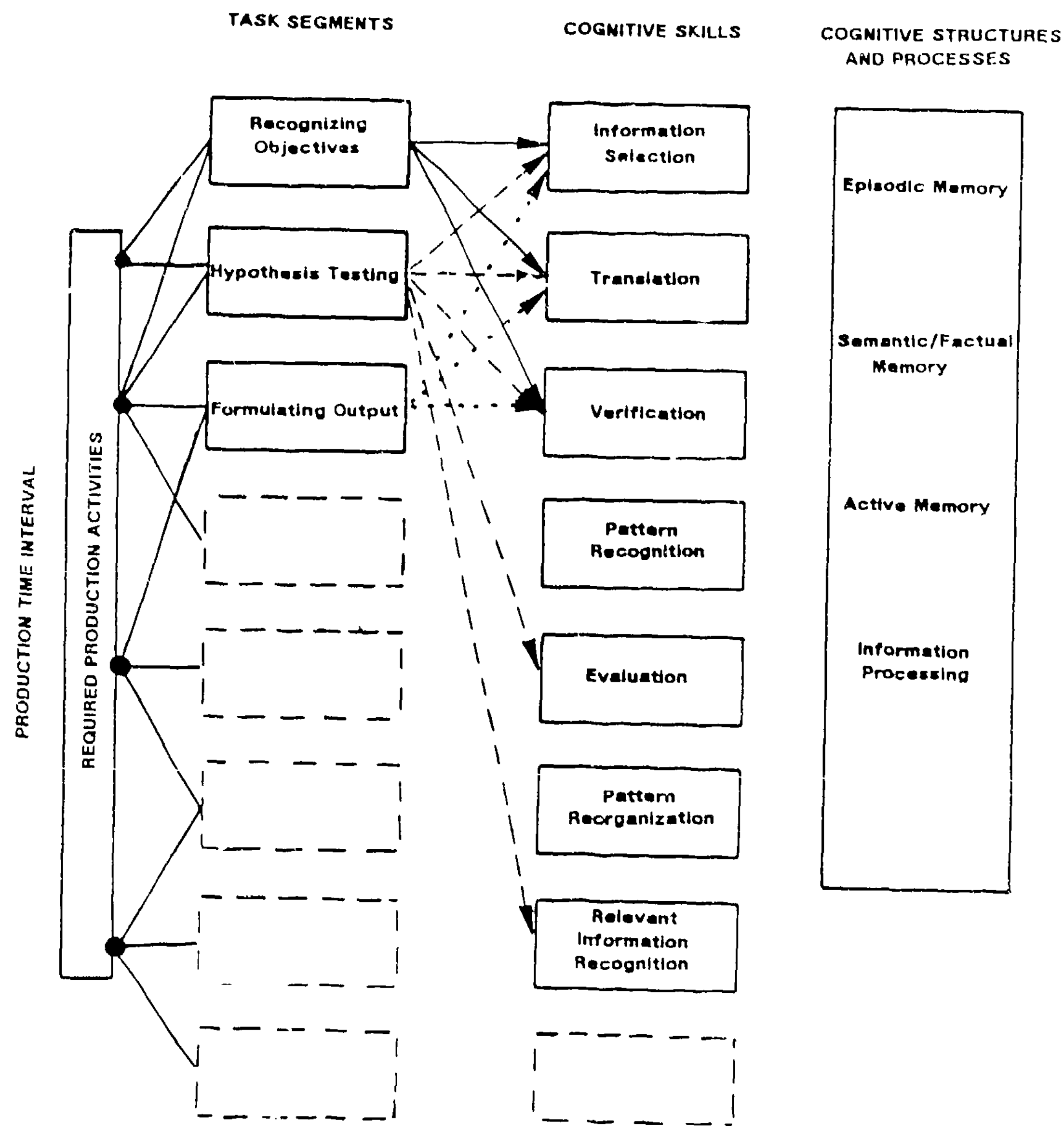

Figure 7-2: Relationship of Cognitive Processing and Production.

- Memory capacity. This refers to all memory stores; in the present context, specifically to long-term memory (semantic/factual and episodic) and active memory. The attributes of interest are size, adequacy of content, and complexity of the organization of memory.

- Storage and retrieval. The skills associated with storage and retrieval concern the adequacy of identifying relevant items to be stored (and, hence, remembered) and differentiating them from irrelevant items. They also include the way an item is stored within the existing memory organization, a process that is necessary for efficient retrieval. For example, if an analyst stores information to the effect that a tank battalion has been sighted, but does not store it within the context of location, time, and so forth, that information is relatively useless.

- Environment. The characteristics of the environment are considered a part of the structure of the cognitive model. The relevant skills, then, are those that are needed to assign meaning to environmental inputs, the most important being pattern recognition, template matching, and problem structuring.

- Conceptual models. The skills associated with conceptual models are those responsible for the development and use of such models, as discussed in Chapter 3. They also include communications skills, since shared conceptual models are required for efficient communication.

- Information processing. This includes several processes within the cognitive model that correspond to various procedural and analytical skills.

Each of the above categories can be represented as a set of attributes, where individual differences are represented in terms of the values of each attribute. For example, the capacity of active memory can be quite large for some individuals, or quite limited for others. Size, therefore, is an attribute which can take on different values. The value of an attribute (as expressed in a particular individual) has implications for understanding performance. In the case of active memory, the value on the size attribute will be positively correlated with attention span (a performance variable). For the ideal analyst, optimum values on attributes must be evaluated for the goals under consideration. Optimum values are not necessarily the same as maximum values. In some cases, a maximum value could interfere with task performance. For example, during hypothesis generation (a task segment), it is quite possible to have so much information in active memory that too many hypotheses are generated, a process that could delay decision making and interfere with the goal of reducing threat. It is important, therefore, to define optimum values for specific mission goals within the context of the triad that consists of threat (red perspective), environment (white perspective), and control (blue perspective). The cognitive model of the ideal analyst, then, is defined in terms of sets of optimum values for each cognitive structure and process, where the values are dynamically adaptive to mission goals.

7.2 The Ideal Product as Threat Model

The "ideal product" is a concept developed by Logicon researchers after extensive investigation into the nature of intelligence production and the cognitive processes of intelligence analysts.

This research developed ... nction that the threat analyses performed by intelligence analysts have co... underlying patterns. These patterns are evidenced in the information flow bet... n analyst and user through reporting and other types of interactions.

This research has established a basis for a generic production structure which meets the analyst's goal of minimizing the users' uncertainties by providing information that maximizes their ability to control threat.

It was also found that the models of threat had to be conceptualized in the context of particular users and environmental contexts to be effective. Thus, impacting on the intelligence products are the multiple dimensions of the battlefield in which individual products can assume format and content variations within various user and environmental contexts.

Since the IMTIA research was per... , the concept of the ideal product has been refined and formalized into the concept of the threat model. The ideal threat model is the equivalent of the ideal product. The following sections describe in detail how to develop a threat model, i.e., how to achieve the ideal product.

7.3 General Steps for Developing the Threat Model

The threat model is a puzzle fitted together from thousands of pieces of information that are related in the context of the battlefield situation. The geographic framework of the threat model and location of friendly and enemy units is the basic structure used for relating the pieces. The time context for each snapshot of the threat model determines which pieces should be included and which ones should be left out. Developing the threat model involves six steps:

- Increasing the level of detail.
- Representing areas of uncertainty.
- Plotting the location of new information.
- ...creasing the level of accuracy.
- Stepping the model forward or backward in time.
- Physical scaling.

The following subsections describe these steps.

7.3.1 *INCREASING THE LEVEL OF DETAIL*

...information is accumulated, the level of detail in the threat model must be ...eased. The frame of reference for the threat model is the topographic map. Two mechanisms can be used for adding more detail to the map: (1) increasing the number of overlays or (2) using smaller scale maps for greater resolution of detail. Map overlays can provide more detail to the threat model without obscuring topographic detail. New material can be separated into overlays that pertain to specific topics. Adding more overlays adds greater detail, while removing overlays declutters the threat model

7.3.2 *REPRESENTING AREAS OF UNCERTAINTY*

As the threat model is being filled in, placeholders and flags may be used to identify missing information and areas of uncertainty. For instance, a symbol for a unit can be represented on the map or adjacent to it, even if its location is not known. The ground trace of a collection mission can be plotted on the map even though the information reports have not yet been received from that mission. Placeholders and flags serve a useful function when they are readily distinguishable from known information.

7.3.3 *PLOTTING THE LOCATION OF NEW INFORMATION*

New data can represent new information, errors, redundancies, or contradictions with existing information. Until that information is evaluated and assimilated into the threat model, it is loosely tied to the threat model by describing it as an information event that can be plotted with respect to place and time in the white geographic framework.

7.3.4 *CHANGING THE LEVEL OF ACCURACY*

New information can change the accuracy level of the threat model. As new information is brought into the framework of the threat model, it is compared with the existing information. The credibility of the new information must be weighed against the credibility of the old information before an adjustment in accuracy is made.

7.3.5 *STEPPING THE MODEL FORWARD OR BACKWARD IN TIME*

Because the battlefield is dynamic, a static threat model is not adequate. The threat model is made dynamic by the process of creating snapshots of the threat model. Each snapshot of the threat model represents some defined time period. A sequence of successive snapshots is an animated view of the battlefield.

The value of using the time dynamics of the threat model is this: Features of the threat model that are not dynamic can be transferred from one snapshot to the next without effort (for example, the performance characteristics of a specific weapon system will not change from one hour to the next, although its physical location might change) and the dynamic features can also be updated without effort or represented as predictions.

Stepping the model backward in time allows many pieces of information to be added that would otherwise not be included in the threat model. For example, information from prior battles, exercises, or training doctrine are useful as a historical base for developing the model. The actual threat model might incorporate information about weapons and tactics that dates back to information sources that are years old. In effect, the principle of "inheritance" is used to fill in information from the historical base.

An important value of the threat model is that the snapshots can be extended into the future as an aid to envisioning and predicting the course of the battle and the expected outcomes of missions. Filling in the future time snapshots requires considerations of plans, trends, contingencies, probabilities, and statistic

7.3.6 *PHYSICAL SCALING*

Events and behaviors are frequently difficult to observe at actual scale. The threat model can be scaled to observe such behaviors in terms of both space or time. Space is scaled in terms of a topographic map. Time can be scaled to any period of interest or to encompass dynamic behaviors.

For example, with a scaled representation, it is possible to determine how far battlefield entities can see, shoot, move, communicate, or jam.

Physical scaling makes it possible to detect.

- Trends.
- Patterns.
- Missing information.
- Errors.

Map-reading skills are a critical requirement for accurate physical scaling in threat modeling. These skills are needed to determine line-of-sight distances, fields of fire, and various aspects of mobility.

7.4 Dimensions of the Threat Model

The threat model can be systematically partitioned so that the massive volume of information represented by the model can be managed. Much of this information can be translated into text, symbols, and graphics, but much of it remains in the analyst's head. Without additional structuring beyond white, red, and blue thinking (see Chapter 8), the analyst would still have great difficulty in coping with the massive volume of information.

Techniques are available to partition the battlefield information so that it is easier to remember and manage. These partitioning techniques also provide a systematic structure that can be used when dividing the analytical workload in an analytical team. This organizational structure can also be implemented in automated data bases that support threat modeling.

The partitioning techniques include:

- Creating descriptions at increasing levels of detail.
- Allowing descriptions with varying levels of precision.
- Partitioning by geography.
- Classifying areas by topographic features.
- Indexing objects by battlefield depth.
- Organizing information by time windows.

- Organizing information by relevance to echelon level.
- Integrating events and information into aggregate elements.

The following subsections describe these techniques for dividing and conquering the complexity of the threat model.

7.4.1 INCREASING LEVELS OF DETAIL

Not all intelligence users need the same level of detail. The threat model can be stratified into overlapping levels of detail. For instance, the opposing force could be described in terms of its hierarchical structure, with increasing levels of detail corresponding to lower and lower levels of the hierarchy. Each level might correspond to a different type of blue usage.

7.4.2 VARYING THE LEVEL OF PRECISION

Not all of the information in the threat model needs to be at the same level of precision. For instance, if only two of the three battalions in an enemy regiment have been detected, the third can be assumed to be present because of enemy doctrine. The third unit can be represented in the threat model, but at a lower level of precision in order to make the model as complete as possible.

Completeness, as defined by the mission objectives, is more important in threat modeling than consistency in precision. Force strengths cannot be estimated using the threat model unless the model is complete. Analysts must know and report the precision of the representations in the threat model.

The most precise information is not necessary to begin formulating the threat model. The threat model can be initially formed by doctrine and then refined as more precise information is obtained. Understanding the needed precision levels will help analysts focus the collection and analysis activities to improve the threat model.

7.4.3 PARTITIONING BY GEOGRAPHY

A straightforward means of dividing the information level of the threat model is to divide it by geographic sectors. This technique is used as a matter of course in the assignment of areas of influence and areas of interest by echelon.

7.4.4 CLASSIFYING BY TOPOGRAPHIC FEATURES

Information about topographic features of the battlefield can be classified so that it applies directly to the type of combat options planned for the geographic area. This type of classification makes it easy to bring the general background knowledge into the threat model. Topographic classifications include:

- Weather options (clear, inclement, monsoon, etc.).
- Day/night options.

- Open terrain options.
- Forest.
- Arctic.
- Desert.
- Mountain.
- Urban.

7.4.5 INDEXING BY BATTLEFIELD DEPTH

From the blue perspective of the battlefield, the red area can be viewed in successive levels of depth. The depth index determines:

- What types of objects are seen.
- How soon the information on the object is needed.
- What level of detail is needed on the object.
- What source is available to provide that information.
- The level of uncertainty concerning the object.

7.4.6 ORGANIZING BY TIME

The threat model can be organized into successive time snapshots to depict the dynamic changes of the battlefield. By limiting the extent of each snapshot, the amount of information to be dealt with can be controlled.

Moving from one snapshot to the next also purges information whose value has diminished. Old information can have an inertial effect that delays the detection of dynamic changes in the battlefield.

Snapshots of wider time scope can be overlaid on narrower snapshots in order to deal with information in greater generality or with patterns that have a slower rate of change. The strategic snapshot of the battlefield is much wider than the tactical snapshot.

7.4.7 ORGANIZING BY RELEVANCE TO ECHELON

The potential complexity of the threat model is reduced long before it gets to the tactical intelligence analyst. The strategic intelligence products that precede the tactical intelligence mission will have defined:

- Where the battlefield is.
- Who the enemy is.
- What the enemy's strategic options are.

- What the enemy's general force structure is.
- What the enemy's weapon technology is.
- What the enemy's initial tactical resources are.
- What the enemy's sustaining capabilities are.

These general strategic options can be furthered stratified for the tactical threat model. For instance, the threat model can be stratified into the following potential options:

- Conventional warfare.
- Chemical/biological environment.
- Limited nuclear environment.
- Strategic nuclear environment.

7.4.8 INTEGRATING THE ELEMENTS OF THE THREAT MODEL

One major task in developing an ideal product is to integrate the elements of the threat model in a way that will satisfy each user's requirements. The pieces of the threat model must be integrated into a meaningful representation of the battlefield that is complete within the mission context. Bringing the pieces of the threat model puzzle together is the process of *seeing the battlefield* in order to accomplish a blue objective or mission.

Dividing the battlefield into its different dimensions creates information chunks that are easier to remember and that facilitate threat modeling. Time and geography are always the reference frameworks that relate the information chunks to each other.

7.4.8.1 Integrating for the Product

To create an intelligence product, various elements of the threat model are selected for integration. A time snapshot is selected that represents the timeframe within which the product user applies the information to combat decisions and the geographic scope of the information is matched to the product user's area of influence and area of interest.

Product context also determines the level of detail necessary for viewing the threat model information. Analysts must consider what terminology and level of detail will be required for the product user to understand the information. For instance, the threat model may include information on each known artillery position. However, the product user may only be interested in the battalions represented by those units.

7.4.8.2 Integrating for Completeness

Completeness within the mission context is the most important aspect of threat model integration. Completeness means:

- Showing the full strength of the enemy force even though only half of the units in the force may have been identified and located.
- Showing a probable position of a unit even though there is uncertainty as to that location.
- Showing the expected enemy course of action, even if it is a guess.

Completeness is what makes the threat model most useful as a decision aid. Seeing the battlefield is seeing the complete picture of the battlefield situation, even if pieces are highly uncertain.

Certain kinds of tools have been devised for keeping the threat model as complete as possible. These aids include:

- *Templates.* A template is a generalized model of the composition of a class of unit, object, activity, or event on the battlefield. A template describes the general features and relationships of features to the battlefield environment. For example, a template of a type of enemy artillery battery would describe the numbers of artillery pieces, supporting equipment, and the general positioning of the pieces when deployed.

  Many different forms of templates are described in the IPB process, including doctrinal, situation, and event templates. Additional templates are useful for describing the signatures of various battlefield objects and activities. Signature templates, in particular, are useful in piecing together information from multiple sources.

- *Tracking.* A track can be used to integrate information that falls into multiple time snapshots, as in the position of a maneuver unit. Positions of enemy maneuver units can be integrated by correlating individual position reports with an assumed track or route. The track of a maneuver unit would appear as a line connecting the points of its past locations.

  Tracking can also apply to maintaining continuity on identifying and locating critical elements of the enemy force. Knowing that continuous information is available on enemy units is a means of reducing the risk of surprise or deception.

  Tracking can also apply to integration of information about stationary objects that have dynamic features. Tracking an airfield would involve following the changes in numbers and types of aircraft, modifications (to runway, defense, and facilities) and activity types and levels.

  Order of Battle data bases are an example of tracking. These data bases contain complete records of the enemy's organization, strength, composition, and characteristics. The form and behavior of enemy units or organizations are included in OB data bases.

  Tracking allows the threat model to provide information on patterns and trends of battlefield activities. Thus, tracking can provide a useful method for identifying unusual or unexpected enemy actions or events.

- *Time Lines.* Courses of action can be more completely modeled in terms of time duration and occurrence of key events if the course of action can be represented as a program of activities and events over time. For example, the event analysis matrix, described in the IPB process, correlates expected events and activities with each NAI and TAI and adds the dimension of time.

- *Networks*. Networks are groups of units linked together to serve some specific function, such as communications, supply, command, or sharing of a common resource. A network may also be used to show the aggregation of subordinate units into a higher-level unit (as in force composition or tables of organization and equipment). Thinking of units as embedded in a network can aid in completing the information in the threat model even if some of the units in the network cannot be identified or located.

  Even if full information is not available on the events in the course of action, the program structure helps to anticipate the duration of activities and the time-spacing between events. For instance, second- echelon staging as a program of activities may be represented so as to determine the time and geographic relationships between indicators of that activity. The same would be true of a river-crossing activity. The events leading up to the river crossing, the scheduling of units crossing the river, and actions following the crossing could be treated as a scheduled program.

7.5 Making Measurements with the Threat Model

Perhaps one of the most useful functions of the threat model is in its capacity for prediction. Prediction must be preceded by accurate measurements of the various elements of the threat model. When integrated within the threat model, these elements can be measured in ways that individual pieces of information cannot.

Scaled measurements can be used to provide quantitative data on enemy capabilities. Time measurements can be used for predicting events. Statistical measurements made on the threat model can identify unusual activities, trends, and patterns.

Three categories of measurement can be addressed using the threat model. These categories include:

- Force strength.
- Uncertainty.
- Risk.

The following subsections discuss these categories.

7.5.1 MEASURING FORCE STRENGTH

The threat model can be used for aggregating the strength of enemy forces now and in the future. The threat model, because of its geographic framework, can be used to compare red force strength to blue force strength on an area basis. Force concentration and force ratios are key indicators used by the commander to evaluate enemy intentions and risk.

The relative combat effectiveness of the enemy can be measured with the aid of the threat model. Doctrine provides a "design strength" of manning level, equipment, reserves against which actual fluctuations can be measured. Making this type of measurement requires continual tracking of the attrition and resupply activities.

7.5.2 MEASURING UNCERTAINTY

Measuring uncertainty involves a number of quantifications. For example:

- Information source credibility.
- False alarm error rate.
- Miss error rate.
- Imprecision.
- Unexpectedness.
- Missing information.
- Inconclusive information.

The ability to recognize these types of uncertainty in the threat model is a required skill of the intelligence analyst. The risks associated with the uncertainties due to the analyst's own skill limitations must also be taken into account.

The following subsections describe briefly these areas of uncertainty.

7.5.2.1 *Information Source Credibility*

Most information in the threat model will have a validity established by belief in the truth of the source and knowledge of conditions under which the information would be true. Information source credibility may be based on the historical success of a source or on the engineering constraints of the system. The predictability of source credibility is generally based on a projection of the historical success rate qualified by environmental conditions.

There are two rating scales associated with an item of information, one rating reliability of the information source, the other rating the accuracy of the information. These evaluations are discussed in detail in Field Manual 30-5, *Combat Intelligence*.

7.5.2.2 *False Alarm Error Rate*

A false alarm occurs when a data item is reported erroneously, for example, if a sensor gives a false reading or if data are misinterpreted.

The false alarm error rate is the ratio of false alarms to correct evaluations. This rate can be heavily biased by the analyst's expectations. If events are expected, they tend to be perceived even if they have not occurred. This type of bias makes analysts susceptible to enemy deception. The ability to recognize situations where false alarms are highly probable is a skill that can protect analysts from the effects of enemy deception.

7.5.2.3 *Miss Error Rate*

A miss error is when an event actually occurs, but is not detected. Miss errors can occur because of incomplete sensor coverage, enemy cover and concealment actions, or because of noise and errors in information. The miss error rate is the ratio of misses to correct evaluations. The result of having a high miss error rate is the risk of surprise.

The ability to recognize situations with high miss error rates is a skill that allows the analyst to compensate for errors by diversifying collection activities and warning friendly forces to be vigilant for surprise enemy actions.

7.5.2.4 *Imprecision*

Imprecision is the degree of uncertainty about a numerical measurement or an object identification. Sensor imprecision may result in uncertainties about the location or classification of an enemy unit. The number of digits used in listing the UTM coordinates on a location implicitly defines the level of precision on the location.

Numerical imprecision may also occur in identifying the size of a force, the performance of a weapon system, or the time resolution of when an event occurred.

An imprecise identification involves ambiguity in classification of size or type. For example, the terms "heavy tank" and "battalion-size unit" reflect imprecision in class identification. Imprecision may also apply to ambiguity of specific unit identities. For example "a battalion of the third armor division" is a less precise identification than "the 42nd battalion of the third armor division."

Using precise terminology when it is not appropriate may be misleading and have negative consequences for the friendly force. For example, transmitting the precise location of a mobile enemy unit without a time qualifier may result in the execution of a useless artillery mission. Knowing how and when to use precision is a skill that the intelligence analyst needs.

7.5.2.5 *Unexpectedness*

Unexpectedness is the level of departure of a measurement from an expected value. The expected value may be based on historical values or trends, doctrine statements, or analogies if the event has not occurred before.

7.5.2.6 *Missing Information*

Missing information may be gaps in battlefield surveillance, apparent missing features in physical models of battlefield objects, missing information on physical attributes of known features, or missing elements that compose units. Being able to identify information as missing rather than as imprecise requires having a template, mirror image, network, or program structure to compare with existing information.

7.5.2.7 Inconclusive Information

Inconclusive information is unexpected and cannot be interpreted in terms of the existing threat model structure. If the unexpected information cannot be attributed to noise, normal environmental variations, errors, or identified battlefield objects, it can still be identified as an information event and retained for future interpretation.

An unidentified moving target detected by a radar can be considered inconclusive information if it cannot be associated with a particular enemy activity. Inconclusive information can be useful if it can be used as a measure of unusual activity or as a guide for directing future collection missions.

For example, construction activities in the enemy's rear area may be observed, but an identification of the type of construction may not be possible. The event is significant if it eventually is identified as a fortification for a command post or a missile installation.

The ability to recognize potentially significant information is a skill that allows analysts to piece together bits of information that by themselves would be meaningless. The threat model provides the time and space framework for retaining these pieces of information until they can be interpreted in terms of some aspect of the enemy war plan.

7.5.3 MEASURING RISK

Measuring risk involves merging risk factors with uncertainty measurements. Risk factors include:

- Enemy force lethality.
- Warning time.
- Number of enemy options.
- Number of friendly options.
- Knowledge of environmental impact on red and blue.

Risk must be qualified by the uncertainty introduced by source credibility, error rates, and imprecision which affect risk factors.

7.5.3.1 Measuring Lethality

Lethality is a measure of the enemy's military capabilities. Lethality might reflect force size, weapon technology, weapon performance, combat effectiveness, force concentration, and sustainability rate. The measurement of lethality is normally done in comparison to the countering friendly force. Changes in lethality are important because they can be indicators of enemy intentions, strengths, or weaknesses.

A commander must be as certain as possible about the lethality of the enemy force. When there is a range of uncertainty about enemy lethality, the commander must plan for worst-case and best-case situations as well as for nominal case. It is the analyst's responsibility to narrow the range of uncertainty about enemy lethality so that the commander does not have to waste planning and mission resources on unrealistic options.

7.5.3.2 Measuring the Number of Enemy Options

Although the number of enemy options can be potentially infinite, the more probable options are the ones that fall into doctrinal patterns and that resemble patterns observed in training, exercises, or previous conflicts. Plausible enemy options can be ranked in order of their closeness to doctrinal patterns. Other factors to consider in evaluating enemy options include:

- Indications of preparations being made for multiple options.
- The mobility of the enemy force.
- The friendly force vulnerabilities that the enemy is most likely to try to exploit.

7.5.3.3 Measuring Warning Time

Warning time is the time available to the friendly force to prepare a response to an identified enemy threat The measure of warning time must be qualified by uncertainties caused by false alarms, miss error rate, source credibility, and missing information.

When exact scheduling of enemy actions is not known, the analyst can measure factors that are indicators of the available warning time:

- Closeness of enemy troops to FLOT.
- Increased mobilization of reserves.
- Increased activity in supply lines.
- Proximity of forces to readiness (time needed to complete final steps of preparations).
- Maneuver capabilities.

7.5.3.4 Measuring Friendly Options

The commander selects the combat options of the friendly force following the principles of war and embodies these options into the operational plan. The analyst's role is to make sure that selected options are workable in light of enemy actions, weather, and terrain. The threat model can be used to identify factors that make selected options more desirable, such as:

- Favorable characteristics of friendly force mobility corridors.
- Collection capabilities to support targeting options.
- Enemy vulnerabilities.
- Critical points in enemy plans.
- Operations security to deny knowledge of friendly plans to enemy.

7.5.3.5 *Measuring Knowledge of the Environment*

Environmental factors, such as weather and terrain, are qualifiers on the effectiveness of both enemy and friendly courses of actio . Risk can be attributed to the impact of these factors on the expected success of a mission. Risk can also be attributed to the balance of environmental knowledge between enemy and friendly forces and their ability to exploit that knowledge.

Uncertainty about the impact of environmental factors on friendly and enemy options could cause the commander to select non-optimum courses of action. Analysts must determine the impact of environmental factors on both friendly and enemy courses of action and convey that information to the user or commander.

7.6 Summary

The threat model is a way of seeing the battlefield. Analysts must use three perspectives in creating the threat model. In THINKING WHITE, the battlefield is viewed in a time and space perspective. By thinking white, analysts give the commander an advantage in exploiting terrain, weather, or resources of the local region.

In THINKING RED, the battlefield is seen from the enemy's planning perspective. Thinking red allows the analyst to predict what the enemy will do in given situations.

In THINKING BLUE, the focus is on the information required to accomplish the commander's mission. Thinking blue allows the analyst to sort threat information appropriately -- exploiting information for immediate needs, storing useful information for later use, and ignoring information that cannot be exploited.

Tables 7-1, 7-2, and 7-3 represent checklists that summarize ways of thinking from each of the three perspectives.

What is the geography of the battlefield?
What is the culture of country area?
What is the history of conflicts in this region?
What is the attitude of the local population toward the enemy force? toward the friendly force?
What is the academic, economic, and technology level of the local population?
How is the local population armed?
How is the population distributed in the region?
What commercial, industrial, and natural resources exist in the region?
What local cultural features (e.g., airfields, railways) can be exploited for military purposes?
How predictable is the weather in the area?
How does the weather affect operations, personnel, trafficability, equipment, and communications?
During what time frame will hostilities occur?
How much time is available for preparation?

Table 7-1. Checklist of WHITE Questions

What is the enemy's doctrine?
How does the enemy prepare war plans?
What are the enemy's objectives?
What is the enemy's strategy?
What are the enemy's operational plans?
What are the enemy's courses of actions?
What are the enemy's tactics?
How does the enemy train?
How is the enemy equipped?
How is the enemy force sustained?
How is the enemy force structured?

Table 7-2. Checklist of RED Questions

What are the BLUE principles of war?
What are the friendly objectives?
What are the friendly force resources?
What is the commander's mission?
What resources does the commander have at his disposal?
What are the priority information needs of the commander?
What are the information needs to execute the mission?

Table 7-3. Checklist of BLUE Questions

8. AUTOMATED SYSTEMS

The objective of this chapter is to describe how automated systems fit into the cognitive processes of the intelligence analyst. There are a limited number of prototype automated systems that support tactical intelligence production and there are several operational systems that currently support strategic intelligence production. Many more automated intelligence support systems are in a requirements definition or development stage. The developers of these systems need an awareness of the cognitive processes of the analysts who will use their systems.

Over the course of the IMTIA study, site visits were conducted to observe and evaluate the use of existing automated systems that support intelligence production. Table 8-1 lists the systems that were reviewed during the course of this study.

SYSTEM	TYPE
BETA	Tactical, Testbed
TCAC	Tactical, Development
ITEP	*TENCAP
DITB	*TENCAP
AMH	Strategic, Operational

Table 8-1. Reviewed Systems
*TENCAP - Tactical Exploitation of National Capabilities

Users, developers, and trainers were interviewed with respect to how analysis was affected by the existence of these systems. The intent was not to study the performance of these systems but to understand how automated supports relate to intelligence analysis.

The observations from these site visits and interviews were integrated with our own experience with automated systems and compared with the implications of the cognitive model. As a result, we have compiled a set of conclusions about common design problems in existing systems and implications for future automated systems.

8.1 Common Problems

In the past, automated systems have been developed with the objective of exploiting some form of data processing functionality (memory, computation, communications) without a clear understanding of how the system will affect the performance aspect of analysis. Many of the problems these systems have experienced in the area of user acceptability appear to be traceable to the lack of understanding of the human performance aspects of intelligence analysis on the part of the system developers. In looking at the information architecture of these systems in relation to the cognitive framework, there are several common inconsistencies that may be the source of usability problems. Four of the most important inconsistencies are:

- The structural features of the automated data base do not match the structure of the analyst's threat model.
- The user interface dialog does not provide for separating the contexts of different users in different roles or different objectives in multiple analysis tasks.
- Display and control arrangements are not tailored to various thinking skills or to variations in skill within the user population.
- Feedback mechanisms between information sources, analysts, and product users are not integral to the system architecture.
- Communication mechanisms in automated systems do not fully exploit the value of shared conceptual models.

These problem areas are further defined in the following paragraphs.

8.1.1 INCONSISTENCIES WITH THREAT MODEL

The threat model is the analyst's means of seeing the battlefield through an abstraction of perceived reality. The threat model is an integrating framework that facilitates multi-source exploitation and multi-disciplinary analytical team effort. Most database aids in automated intelligence support systems address some aspect of threat model information (e.g., order of battle, operations plan, terrain, weather). Current systems have database structures that are inconsistent with the threat model in one or more of the following ways:

- The data cannot be tailored to the mission context.

  Information, such as order of battle, is sensitive to the mission context and environmental factors. Multiple representations or adaptivity features are required to tailor the threat model data to a particular situation.

- The data cannot be easily related to a specific time-space framework.

  All threat model information must be placed in the time-space framework relevant to the mission.

- Data are not classified as hypothesis vs. observation (facts, evidence).

  The entire threat model is a hypothetical structure. The hypothetical structure provides the means of interpreting new information. The hypothetical structure should be distinguishable from the information gathered to substantiate or repudiate the hypothesis.

- Data cannot be selectively displayed (using geographic boundaries, time window, entity class, or entity parameters) as selection criteria.

  The totality of threat model data requires that mechanisms be used for decluttering the user's view of the threat model. Selective retrieval and display is a required for effective use of a threat model database.

- Data cannot be portrayed from different perspectives.

The threat model has three major perspectives -- WHITE, RED, and BLUE. In addition, specific uses of threat model information may require varying levels of detail or resolution. The ability to shift perspectives enables the analyst to deal with much more information than is possible with a single perspective.

- Information cannot be dealt with in sets.

  Within the battlefield, there are numerous objects that can be treated as members of a class (e.g., type of unit or equipment) or set (e.g., force composed of individual units, communication net, command structure, events occurring in line of communication). Databases must be able to recognize the association of objects or information events as part of a set.

8.1.2 LACK OF MULTI-PROCESSING SUPPORT

Automated systems in general are not structured to support the multiple processes of the total analytical procedure. On the surface, analytical procedure appears to be data driven. Most ADP systems have assumed a data-driven interaction, either by incoming raw intelligence messages or by commands from the user. The IMTIA cognitive model has shown the analytical process to be objective driven, but with interruptions driven by opportunities to exploit information sources. For an automated system that hopes to follow and aid the analytical procedure, there must be provisions for supporting multiple on-going analytical processes that run concurrently and that interrupt each other.

Because most system designers have not been aware of a common structure in the analytical process, there has been no attempt to support that structure or the processes that occur within that structure.

8.1.3 COMPENSATION FOR USER SKILL LEVEL

Little attention has been given in current systems to varying skill levels in the user population. Intelligence analysts represent many different skill levels because of personnel rotation, rank, discipline, education and experience. A system designed for the casual user may be cumbersome and frustrating for the experienced user. A system that can only be operated by an experienced user places inordinate demands on training resources and risks failure under the stresses of battlefield or crisis situations.

Systems that deal with the issue of varying user skill levels are more difficult to design and guidelines for dealing with this issue have not been available.

8.1.4 LACK OF FEEDBACK MECHANISMS

The IMTIA study clearly identified the role of feedback in the communication processes between the analyst and the intelligence user and between the analyst and information sources. Because most of the feedback channels are informal in non-automated intelligence production systems, the feedback mechanisms may have been overlooked by the developers of automated systems. Feedback is an essential feature in controlling information overload from collection system inputs and in the generation of quality intelligence products. Feedback is the natural mechanism that the analyst uses in tailoring intelligence products to the specific needs of user. Because feedback mechanisms operate over a long period of time, its importance is not apparent in systems with stable configurations and operating procedures. However, in a dynamically-changing battlefield environment, crisis situation, or in newly formed analytical teams, the criticality of feedback is more apparent.

8.1.5 COMMUNICATIONS WITHOUT SHARED CONCEPTUAL MODELS

The most critical problem in tactical intelligence production is communications. Tactical communications are vulnerable to jamming, environmental factors, fires, overloading, and disruption during maneuver. Because of these factors, tactical communication channels do not have predictable bandwidths, availability, reliability, and throughput times. Strategic communications as well may be affected by delays caused by peak period overloads, manual handling, and misdissemination of messages. None of the ADP systems reviewed addressed the problem of achieving effective communications under these conditions.

The observation of informal communications in analyst activities has shown that there are natural mechanisms for dealing with the problems of unreliable communication channels. These mechanisms exploit shared conceptual models as discussed in Chapter 3. Automated communications have not yet been designed for exploiting the concept of shared conceptual models. Common problems are that more data are sent than needed, or critical data needed to establish a context for interpretation are missing.

Communications designs do not use a cognitive framework for deciding the relative importance of information; under adverse communication conditions the most important information does not always get sent first.

8.2 Reviews of Intelligence ADP Systems

The reviews of automated systems conducted under the IMTIA study were not aimed at evaluating the performance of the automated data processing functions. The objective was to look for successes and failures that were related to human cognitive processes.

Current systems are designed with the primary objective of exploiting sensor, communication, or adp technology rather than aiding the cognitive processes of the user. User interface configurations are designed in an ad hoc manner and do not reflect a systematic application of design guidelines (primarily because adequate guidelines have not been available). As such, instances where automated systems successfully support the cognitive processes of the analyst are largely due to the intuition of the designer or have evolved with operational experience.

Failings in many cases could have been avoided with the application of guidelines that addressed the issues of cognitive performance.

A synopsis of the system reviews is provided below to illustrate some of the critical issues in future system developments.

8.2.1 *BETA*

BETA was designed as a testbed system to demonstrate the utility of multi-source intelligence exploitation or targeting and situation assessment.

One of the most important features of BETA is its capability to allow users to selectively call up and display information from the shared database. Each user's display can be scaled to the geographic area of interest and can display battlefield entities selected by by class, by time parameters, and by specific attributes of the entity. The selective display features are controlled by the user through the use of query structures that act on a shared database.

In essence, the BETA user display is adaptive to the role and interests of the user. The BETA user command language, however, is not adaptive to the role and skill level of the user. Although the use of menus and forms makes it possible for a relatively inexperienced user to exercise the system functionality, the interactive dialog can be very cumbersome for the experienced user.

BETA lacks desirable feedback mechanisms on what the automatic correlation algorithms are doing and lacks easily modifiable templates for entities represented by the system.

An important feature of the BETA system is that it provides graphics communications for conveying the results of target analysis and situation assessment.

Many of the functions of BETA map into the idealized threat model structure presented in Chapters 6 and 7. The most important feature missing from BETA's threat modeling capability is the lack of time snapshot partitioning. The user is unable to "back up" the displayed time window or "project" a future time snapshot. This missing feature makes it impossible for the user to go back and reinterpret sensor reports against a new hypothesis or to project an outcome of a situation.

8.2.2 *TCAC*

Very little information was available on TCAC at the time of the IMTIA system reviews. Comments made by analysts during interviews reflected a common concern about TCAC's lack of a geographic framework as an integral part of its display capability. The implications of the threat modeling study are clear about the need for a geographic framework in all forms of tactical and strategic intelligence analysis.

8.2.3 *ITEP*

ITEP is a product of the TENCAP Program. TENCAP (Tactical Exploitation of National Capabilities), is a program designed to provide access to National Technical Means intelligence products at the tactical level. ITEP is an interim system that was designed to exploit ELINT intelligence.

Clearly, the most important issue demonstrated by ITEP is the need for the analyst's involvement in the system development process. ITEP is regarded by users as a very successful development effort. Much of ITEP's success is attributed to the heavy involvement of intelligence analysts in evolving the functional features and interactive capabilities. The user interface is highly interactive and the analyst is involved in all analytical decisions.

The user interface is not designed for a casual user.

8.2.4 *DITB*

DITB is another product of the TENCAP program that is aimed at imagery exploitation. This system demonstrates the importance of sharing information on collection plans and requirements in order to fully exploit intelligence gathering resources. DITB as well as ITEP demonstrate the utility of reducing the time delays in dissemination of collected intelligence.

8.2.5 *AUTOMATED MESSAGE HANDLING*

The bulk of raw intelligence data and many intelligence products are carried through the media of digital communication networks as electrical messages. These networks also carry requirements, queries, and responses as messages. Automated message handling capabilities were introduced into the intelligence environment during the 70's to deal with the problems of increasing message volumes, manual handling delays, crisis peak loading conditions, new requirements from new collection capabilities, and need for more rapid and accurate dissemination.

Automated message handling systems also make it possible to provide direct updates to intelligence community databases such as DIAOLS/COINS.

Automated message handling capabilities were first introduced at the CIA and DIA and subsequently to military commands. AMH is gradually being introduced into the tactical environment starting with Echelons above Corps.

The most important cognitive aspect of these automated message handling systems in intelligence is that dissemination is controlled by user interest rather than by distribution list assigned by the sender. Dissemination control is exercised at the receiving end rather than the transmitting end. This is an extremely important characteristic of intelligence distribution that facilitates the exploitation of all sources of information.

Intelligence analysts need to be in control of the information-gathering process. The ability to select information from the electrical message carrying networks by automatic filtering is a critical capability required to cope with information overload in the modern intelligence environment.

8.3 Future Implications

The results of the IMTIA study have direct implications for the design of future automated intelligence support systems. The general implications are:

- The threat model can be used as a guideline for the organization of database structures to support the intelligence analyst.
- The steps required to build the threat model can be used as a checklist for functions required to support the storage and retrieval of intelligence data.

- The design of interactive dialogs must take into account the multiplicity of analysis tasks. Each analysis task carries with it a different objective, differing information needs, and differing procedure requirements.

- Analysis tasks adapt with the changing mission needs. Automated aids that support the analyst in meeting mission information requirements must be adaptable to the mission parameters.

- The nine thinking skills in the cognitive procedure provide a framework for the design of an interactive dialog between the analyst and the automated support system. Each skill provides a focal point for the design of display and control features of the user interface. The general sequence in which these skills are performed provides a prototypical order for automatic sequencing of machine-initiated help or cognitive aids. Sequences can be named and identified with the context of a particular task/mission so that sequences can be interrupted, saved, resumed, or repeated automatically.

- The IMTIA model of communications is a model of normal informal communications. The analyst in day-to-day activities uses shared conceptual models as a foundation for communications. Informal communications are extremely flexible in adapting to media and time constraints.

  Day-to-day interaction between parties establishes a broad base of shared conceptual models. In informal communications, once a context has been established, the actual information exchange can be very brief but achieve a high level of understanding. This is especially important when the time available is extremely limited.

  Automated systems can be similarly designed by organizing information into context-specific networks (e.g., artillery targeting, EW targeting, weather, OPSEC, etc.) Many context-specific networks can be mapped onto a single digital message network. Modern communications protocols can be utilized for error control and allocating available bandwidth between the multiple networks.

  Automated communications should be based on exploiting the nature of shared conceptual models in order to achieve understandability and effectiveness. Designers must recognize the multiplicity of the information networks that permeate intelligence operations, each using different conceptual models of the real world. Because of the multiple contexts in which the same information may be used, communications designers must recognize the need to tailor information to a particular user or usage. Although the number of logical networks may be more numerous under this approach, the actual data transfer rates can be minimized by exploiting existing shared knowledge between sending and receiving parties that is context dependent. Communications systems that do not exploit context must transmit substantially more data in each message to convey the same amount of information.

The use of a cognitive framework for the design of the user interface is being pursued under an on-going research project sponsored by ARI. (Research on Human Factors in Design for C^3I, Contract No. MDA903-81-C-0579.) This research effort is aimed at developing guidelines for system developers who wish to incorporate adaptive user interface features.

9. RESEARCH, DEVELOPMENT, AND TRAINING ISSUES

The eight previous chapters have summarized and discussed current cognitive issues in performing intelligence analysis. Some of these issues have direct implications for training; others raise questions that require further research and development. Further research would in turn provide clarification and understanding that would be applicable to improved training methods.

9.1 Cognitive Processes

Some important problems raised in analyzing and evaluating cognitive processes and performance in intelligence analysis are described below.

9.1.1 TASK SEGMENTS AND SKILLS

While the task segments underlying analytic performance have been identified, the actual cognitive skills required to execute the task segments have not been itemized individually. The general skills described in Chapter 4 apply to all task segments. As described in Section 7.1, it is hypothesized that there exist very specific cognitive skills pertinent to the individual task segments. These should be identified individually and training materials developed, tailored to the individual task segments.

The different task segments are associated with different biases and are differentially affected by the cognitive biases discussed in Section 2.4. The relationship between task segments and biases should be investigated. Such an investigation could begin with a case study review of intelligence products to identify where and how cognitive biases might have led to misleading or erroneous predictions or situation assessments.

9.1.2 TRAINING IMPLICATIONS FROM THE COGNITIVE MODEL

The various aspects of the cognitive model, as described in Chapters 2 through 5 have numerous implications for training.

Because of the importance of decision making in intelligence analysis, it is imperative that more research be devoted to the types of decisions that analysts have to make, how they make them, and how they affect the intelligence product. This would be a high pay-off area for research, since analytical thinking covers an extremely broad and complex domain. Though much is known about decision theory and rules for application, it would be detrimental to train analysts using extant knowledge in decision theory and by providing them with a few formal rules without first investigating the context and contents of analytic decisions.

While there exist numerous automated and non-automated decision aids, many of these aids are not appropriate for intelligence analysis because the quantity and quality of information necessary to utilize the aids in the intelligence arena is not available. However, there exist certain recurrent problems encountered when making decisions in the intelligence context that are tied to limitations of the human information-processing system, and there are fundamental procedures that would prove useful in dealing with these problems.

The development of effective analytical thinking is likely to proceed through experience with relevant classes of examples. From such experience will emerge an awareness of common pitfalls inherent in analysis as well as procedural guides and decision paths to maximize the quality of performance. Toward this goal, a selective list of fundamental concepts and problem areas in the context of operational intelligence could be prepared for inclusion in a training program. Also, a limited set of examples could be developed such that useful guides (procedures) for dealing with the problem areas can be illustrated and imparted effectively to the analyst trainees. The suggested procedures would serve to develop a general attitude about problem solving and decision making that is conducive to optimizing analytical thinking. Although the trainee may never encounter the precise events described in the examples, experience with the important problem areas and useful modes of solution (the analytical processes) should generalize to a broad class of similar situations.

Among the concepts and problem areas in analytical thinking that should be considered for inclusion in a training program are:

- Inflexibility of thought (cognitive entrenchment, e.g., confirmation bias).
- Separation of relevant from irrelevant information (e.g., unwarranted hypothesis switching).
- Filtering biases (selectivity, polarization).
- Interpretation of sparse or uncertain data (caricature effect).
- Memory access shortfalls (similarity effects).
- Information management (summarizing, sorting, assessing trends, checklists, memory aids).
- Fallacies of logic (e.g., the "gambler's fallacy" in prediction).
- Asking the right questions (recognizing goals).

Among the general decision guides to analytical thinking that might be addressed are:

- Seeing the total picture (avoiding over-focusing on details).
- Withholding judgment (hypothesis testing as an iterative process).
- Using models (doctrine, templates, prototypes).
- Generating hypotheses based on partial information.
- Changing perspective (restructuring problems).
- Understanding uncertainty and reliability (will to doubt).
- Using stable substructures.
- Discussing problems and decision alternatives with others.

9.2 The Analyst/User Dialog

The importance of communication in general, and between analyst and user specifically, should be explored more thoroughly. Ways to optimize the development and use of shared conceptual models to enhance communication and reduce errors and misunderstandings should be investigated. There are two parallel areas of inquiry relevant to communication, namely by:

- Types and areas of communications (e.g., which ones are most important, which ones might increase danger if misunderstandings occur).
- Types and areas of misunderstandings that are known to occur.

Inquiries should begin with interviews and result in lists, hierarchically organized by importance, of these two areas. Among the specific issues to be investigated are the following:

- The analyst must have an adequate understanding of how the intelligence product will affect the user's perception of threat. We know that the desired reaction is for the user to perceive an increased level of control and a reduction in danger. The first research question, therefore, concerns the measurement requirements for determining any changes in the analyst's and the user's perception of threat.
- Current feedback to analysts is generally informal or non-existent unless the analyst is in direct contact with the user. Feedback mechanisms are required for the analyst to know if these effects are being achieved. The following questions should be investigated:
  - What are optimum feedback mechanisms?
  - How can they be exploited?
  - How can their effectiveness be measured?
- Shared conceptual models have the potential for being exploited to reduce errors and costs of battlefield communications, as well as for improving the commander's timeline for control. Ways of measuring the efficiency of SCMs are needed to justify revamping current communications concepts.

  There are several research questions that deal directly with the way SCMs, as well as CMs, are generated and used in information processing, analysis, and communications:

  - What are the characteristics of the cues that allow for the "best" (most complete, most appropriate) retrieval from external memory?
  - What knowledge items do we need within our own CMs in order to make use of external memory?
  - What are the best retrieval cues to access other CMs within one's own memory or to access external memory? Are they the same?
  - What types of informational items *have* to be shared for SCMs to be optimally effective? Intuitively, one might suggest the following as important common factors for effective SCMs:

— Context, framework.

— Goals.

— Language.

— Affective value of CM.

— How can effective SCMs be generated?

— How can the effectiveness of SCMs be measured?

If some of these questions could be determined, then training materials could be structured so as to include appropriate information to generate SCMs and appropriate retrieval cues for correct access to internal and external memory.

Summary Questions on research involving SCMs include:

- How are SCMs established and can the process be speeded up?
- How can the shared aspects of conceptual models be identified?
- How can areas of misunderstanding be identified?

9.2.1 IMPLICATIONS FOR TRAINING

The views presented here concerning CMs, SCMs, and goals, have several important implications for understanding learning, retention, and recall, and hence, for the development of training materials, for education, for training new skills, for the maintenance of skills, and for improving communications within the intelligence community.

Some of these implications are as follows:

- It is important to develop a common framework among analysts concerning the goals of analysis, its organizational basis, and its role within the military community and for the overall goal of national defense. This framework should be shared at all levels of analysis (horizontally and vertically) and it should be shared with the users.

  Developing such a framework has two consequences:

  — It provides the new analyst with an organized structure (a new CM in memory) within which to store new learning materials. The alternative is that new materials must be stored in existing CMs, carried over from earlier training. These existing CMs may be quite inappropriate for organizing new materials, and the result is confusion and/or slower learning.

  — It sets the context for establishing SCMs between analysts, and it provides the basis for the analysts themselves to establish SCMs with their clients.

- The goals and subgoals of analysis should be clearly spelled out and invested with affective values so as to increase the importance (and hence, the speed of learning and ultimate performance) of the CM that is being established.
- Once the framework has been established, the training materials to be presented should always be related to that framework. Analysts should understand how hypothesis generation, for example, is related to the production task, the mission

requirement, and the goals of analysis.

- Access to existing CMs: It is important to relate new materials to items that are already in memory. For example, if an analyst has a good background in mathematics and statistics, it is important to insure that the connection is made between the new material to be taught and the relevant background knowledge. In other words, training materials must be developed based on an understanding of the trainee's available CMs and a clear identification of the objectives and the goals of training. The taxonomy of knowledge described in Section 3.3 should be expanded to include individual analysts' existing knowledge bases *and* the required knowledge categories for optimum performance.
- Training and knowledge maintenance must address the problem that analysts have when they change jobs or when they are transferred from one theater of operation to another. The descriptions and attributes of CMs (Section 3.2) suggest ways to make such changes easier for the analyst and more effective for meeting production requirements.
- The views concerning the nature and characteristics of CMs should be considered when developing automated databases as aids to analysis.

9.3 Goal Orientation

The IMTIA cognitive model emphasizes the importance of a context-specific goal orientation in guiding analytic performance. Analysts must know their goals and share goals with other members of the intelligence community to fulfill mission requirements effectively. At the same time, these goals must be explicit for the ideal product to be effective as an evaluation tool. Some research issues are discussed below.

9.3.1 LEARNING GOALS

Analysts should be encouraged to learn how to identify their goals and how to use goals in structuring their tasks and future training requirements. Without goal direction, some analysts may have a great deal of difficulty in determining what is important for them to know at any given time or how to process what they know. One way to increase the likelihood that analysts will learn and aggregate the appropriate data elements in an efficient manner is for them to adopt or be provided with explicit learning goals.

Learning goals might take the form of questions, or they might simply be statements to "learn about X". In addition, the goals could be stated generally (e.g., "learn about the overall threat of enemy forces in Sector X"), or they could refer to specific bits of information (e.g., "learn about the movement of maneuver units in Section X"). The more specific the learning goal, the greater the chance that the analyst will be successful in mastering the goal.

The use of goals in learning complex materials demonstrates that learning goals induce the learner to process the material in such a way that performance on test questions (usually sentence completion items) referring to the goal-relevant material is improved. This improvement cannot be explained solely as a redistribution of processing time. The extent of the improvement is somewhat dependent upon the number of goals to be mastered and the ease with which the learner can locate the appropriate material in a text. With a greater number of goals, most subjects take longer to study the material and they are less likely to learn the information relevant to each goal. If all of the data that are relevant to a particular goal are not located together in the information flow, then it will sometimes be the case that only the information contained in the first reference to the goal-relevant data will be thoroughly studied (Gagne & Rothkopf, 1975). Therefore, there are some limiting factors in adopting learning goals as learning guides, and the limits are dependent upon both the learner and the materials. The available basic research suggests that each analyst should (a) adopt only a limited number of goals to guide performance and (b) acknowledge potential interpretive biases caused by concentrating too heavily on the initial information pertinent to the goals. However, no research exists on learning improvements with multiple goals when those goals are hierarchically organized, as proposed in Section 5.1. It is likely that multiple goals, when hierarchically organized, will enhance learning rather than impede it. This might be a fruitful and interesting area for investigation.

9.3.2 *SHARED GOALS*

In developing shared conceptual models and in identifying relevant goals, a connection must be made between the goals that are to be shared and goals that are already important to the individual. Individuals have different goals, but to optimize teamwork, there should be some shared goals at some level of the hierarchy. Both during training and in the work setting, it is suggested that **the common goals of analysis be made personally important for each analyst.**

Shared goals promote the development of SCMs. Though analysts need not accept the users' goals as their own, they do need to know and understand them.

For purposes of training and improvement of analytic performance, it is necessary to identify a hierarchy of goals, subgoals, and tasks and to relate this hierarchy to the cognitive skills required to perform the task.

9.4 Issues Related to Threat

Threat is one of the primary conceptual issues that intelligence analysts deal with. A threat model has been developed by Logicon to serve as a shared conceptual model between analysts and users, and to provide a basis for making more accurate intelligence evaluations and predictions. Much research remains to be done, however, for the purposes of the threat model to become fully realized.

Research related to threat can be divided into two categories:

1. Research related to the *perception* of threat.
2. Research related to the *parameters* of the threat model.

9.4.1 *THREAT PERCEPTION*

There are several areas with potential payoffs for further research in evaluating and measuring threat perception.

1. The payoffs are in selecting optimum reporting rates for threat information to ensure that the user can react with control. Too frequent reporting may reduce the significance of changes or decrease the user's ability to detect trends. Too infrequent reporting may decrease the user's ability to respond without panic.

   Research in this area would be concerned with ways to measure the user's reaction to threat information as a function of reporting rate.

2. The user's reaction to threat in general involves a decision regarding allocation of resources for control. The impact of uncertainty is to reduce the user's perception of control and increase the probability of errors in battlefield resource allocation.

   Research in this area would be directed at mechanisms to measure the user's level of uncertainty as a means of feedback to the intelligence production operation.

3. Assuming that the Milburn and Watman (1981) model is valid, it would be useful to devise means for an objective evaluation of observable behavioral responses (i.e., sense of comfort, challenge, alienation, panic) associated with perception of threat and control. Research questions would deal with the differences between such observable responses in the strategic and the tactical battlefields. A possible approach would be to review intelligence cases with these factors in mind, namely perception of threat, available physical control, and physical responses associated with different degrees of each. Such a review should attempt to determine if a correlation exists that would validate the Milburn and Watman model.

4. An additional research area concerns the problems of the extraneous factors that affect intelligence analysis and reporting, as discussed above (i.e., national policy, user idiosyncrasies, etc.). While not strictly a problem of intelligence analysis *per se*, it is obviously a source of many poor analytical products.

   The fact that so many extraneous factors impact adversely on the intelligence product is a matter of great concern to observers of and participants in the U. S. intelligence community. The IMTIA studies suggest that these problems are primarily due to a lack of shared conceptual models, shared goals, and to poor communication. The IMTIA cognitive model contains several useful concepts that, if applied, can help alleviate these shortcomings of the intelligence production cycle.

9.4.2 PARAMETERS OF THE THREAT MODEL

As discussed in Chapter 6, the threat model has three major aspects: white, red, and blue. Each of these is made up of numerous elements that have variable impacts on the implications derived from the model. The implications of concern to intelligence analysts are:

- How to assess threat.
- How to assess threat credibility.
- How to communicate threat.

- Analysts' and users' reactions to threat.
- How to evaluate threat.

It is possible that these issues are treated differently by analysts as they view the battlefield from the white, red, or blue perspective, respectively. It might be interesting to investigate this idea.

There would also be a high pay-off value in developing other notions underlying the threat model.

For example, not all elements of the threat model have the same relative importance for the various analytic tasks. Research in this area would consist in identifying the relative importance of the threat model elements for assessing situations, making predictions, or evaluating and dealing with uncertainty.

A better understanding of how uncertainty and risk affect analytic performance and products could make a significant impact on training. For example, some research should be devoted to identifying different *types* of uncertainties, such as uncertainties concerning:

1. Currently existing physical structures (e.g., tanks, enemy installations).
2. Future physical structures (e.g., new weapons).
3. Current non-physical red elements (enemy doctrine).
4. Future non-physical red elements (enemy intentions).
5. Current white elements (given inadequate maps, for example).
6. Future white elements (e.g., weather).
7. Current and future blue elements (e.g., availability of resources).

These uncertainties are categorized by "types". The question is, do the types of uncertainties have differential effects on the tasks. Also, are the types of uncertainties correlated in some way with the judged degrees of uncertainty that a commander might have? That is, are uncertainties treated differentially depending on type? Given certain degrees of uncertainty, how are predictions affected? Specifically, are probabilities assigned differentially?

Other questions related to uncertainty might be asked, such as:

- What is the judged risk, given different types of uncertainties?
- How are the probabilities of events treated, given differential judged risk?
- How do analysts/commanders estimate reliability, validity, or countering capabilities of various types of information?

All these factors should be more carefully evaluated, the literature searched for information on these factors, and a research program designed to answer some of the more important questions.

In summary, the following issues related to the threat model should be investigated:

- The relative importance of the parameters of the threat model as they impact on the prediction of threat.

- The dynamics of the parameters; i.e., which factors change faster than others and how these changes impact on each other.
- The effects of different degrees of uncertainty on decision making (i.e., humans tend to deviate from normative models of decision making: are these deviations a function of the uncertainties associated with the different factors that need to be considered when making decisions?).
- Whether there are different *types* of uncertainty and whether these types have a differential impact on decision making and strategic predictions. For example, are uncertainties related to physical items (e.g., existing enemy installations) treated differently than uncertainties related to hypothesized behavioral items (e.g., future troop movements or enemy intentions)?
- Whether differences in uncertainty types affect how probabilities are assigned, how risk is perceived, and how validities, reliabilities, and countering capabilities are estimated.
- How different degrees of uncertainty affect the product outcome or the reporting of the product.

9.5 The Ideal Product

The concept of the ideal product arose out of the need to define a baseline state for the cognitive model. That is, an assumption was made that one can define an ideal analyst performing ideally and producing an ideal product. This baseline state would serve as the evaluation criterion for actual performances and products. The differences between the ideal and the actual would be used to identify training needs, as well as areas where maintenance of knowledge or skills should be focused. These assumptions should be investigated for their validity and usefulness.

9.6 Conclusion

Several research topics and training issues have been discussed. No specific methods have been proposed for actually performing experiments. In general, however, most issues discussed could be subjected to controlled experiments on the one hand, or could be usefully investigated by combining in-depth interviews of on-the-job intelligence analysts with results from the existing cognitive and analytic literature.

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