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REVIEW AND EVALUATION OF ADVANCED BEHAVIORAL SCIENCE TECHNIQUES FOR INDICATIONS AND WARNING APPLICATIONS

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Synectics Corporation

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REVIEW AND EVALUATION OF ADVANCED BEHAVIORAL SCIENCE
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Synectics Corporation

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13. ABSTRACT

The essential purpose of this project is to exploit techniques developed under The Cambridge Project: Computer Methods for Analysis and Modeling of Complex Systems and by the Center for Computer-Based Behavioral Studies (CCBS) for demonstrated aid to performance in the Indications and Warning (I&W) area of military intelligence. This Technical Report summarizes progress during the half year beginning in October of 1972.

An advanced aid to I&W performance can be conceived to have five major components, and CCBS and The Cambridge Project can contribute to the formulation of each.

1) Machine-aided input scanning can facilitate the immediate presentation of priority intelligence input as well as helping to index materials for more facile retrieval. 2) File manipulators can assist I&W personnel in relating the existing body of data to current problems or to new information. 3) Inferential models may be able at least in some limited ways, to help I&W personnel to analyze the threat implied by the pattern of information currently available to them. 4) Proper data base architecture can help to make needed information more accessible to I&W personnel. 5) Suitably designed displays/editors can provide I&W personnel with a window to the existing body of relevant information, with means of structuring that body of information in accordance with their needs, and with effective means of structuring communications.

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Text editing						
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Statistical models						
Technology transfer						

**REVIEW AND EVALUATION OF ADVANCED BEHAVIORAL SCIENCE
TECHNIQUES FOR INDICATIONS AND WARNING APPLICATIONS**

James W. Altman

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PUBLICATION REVIEW

This technical report has been reviewed and is approved

A handwritten signature in cursive script, appearing to read "Samuel D. Carl". The signature is written in dark ink and is positioned above a horizontal line.

RADC Project Engineer

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The essential purpose of this project is to exploit techniques developed under The Cambridge Project: Computer Methods for Analysis and Modeling of Complex Systems and by the Center for Computer-Based Behavioral Studies (CCBS) for demonstrated aid to performance in the Indications and Warning (I&W) area of military intelligence. This Technical Report summarizes progress during the half year beginning in October of 1972.

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SUMMARY

This document presents the results of the first six months of effort on Contract Number F30602-73-C-0052 entitled "Review and Evaluation of Advanced Behavioral Science Techniques for Indications and Warning Applications." A concept of an advanced Indications and Warning (I&W) aid is presented, as well as a description of testbed systems capable of supporting demonstrations utilizing this aid or a simulation thereof. The applicability of various techniques from the Cambridge Project and CCBS are assessed in a discussion of five distinct components of an advanced I&W aid:

1. Input scanners
2. File manipulators
3. Inferential models
4. Data bases
5. Interactive displays/editors

Project plans are then discussed.

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1. Input scanners
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1. INTRODUCTION

The essential purpose of this project is to exploit techniques developed under *The Cambridge Project: Computer Methods for Analysis and Modeling of Complex Systems* and by the Center for Computer-Based Behavioral Studies (CCBS) for demonstrated aid to *Indications and Warning (I&W)* performance.

This interim report is concerned with the status of the effort in terms of advanced computer-related behavioral science aids which are applicable to I&W operations. Specific sections of the report include:

1. Concept of an Advanced I&W Aid, which presents a discussion of specific operational areas in which behavioral science techniques are expected to have their greatest impact.
2. Testbeds, which discusses the study aids, scenarios and data bases, and operating systems which will be required to support a demonstration of computer-related techniques.
3. Discussion of Specific Operational Areas, including:
 - a. Input scanners
 - b. File manipulators
 - c. Inferential models
 - d. Data bases
 - e. Interactive displays/editors
4. Project Plans

2. CONCEPT OF AN ADVANCED I&W AID

There are many possible ways of organizing candidate techniques to support I&W. We have found organization according to a functional system concept such as is illustrated in Figure 1 to be most useful. The major components of such an aid are as follows:

1. Input scanners. This component will perform various operations aimed at reorganizing and enhancing input data in the form of messages, digital data associated with graphic input, and portions of reports in digital form. It will include capabilities such as header analysis, text reformatting, thesaurus generation and lookup, text parsing, and theme encoding.
2. File manipulators. This component will provide personnel with the capability to structure, interact with, summarize, merge, and perform other operations on data files with which they are concerned.
3. Inferential models. This component will bring together the methods of inferential statistics with the substance of I&W technology. Of critical importance here is to assure that I&W personnel will be aware of the assumptions which constrain the validity of calculations concerning event probability, unusualness of events, and degree of threat.
4. Data bases. This component will involve the conventions by which media and modes of storage will be defined.
5. Interactive displays/editors. This component will provide I&W personnel with a window to their data files and a capability to organize data in a form suitable for reporting and/or storage.

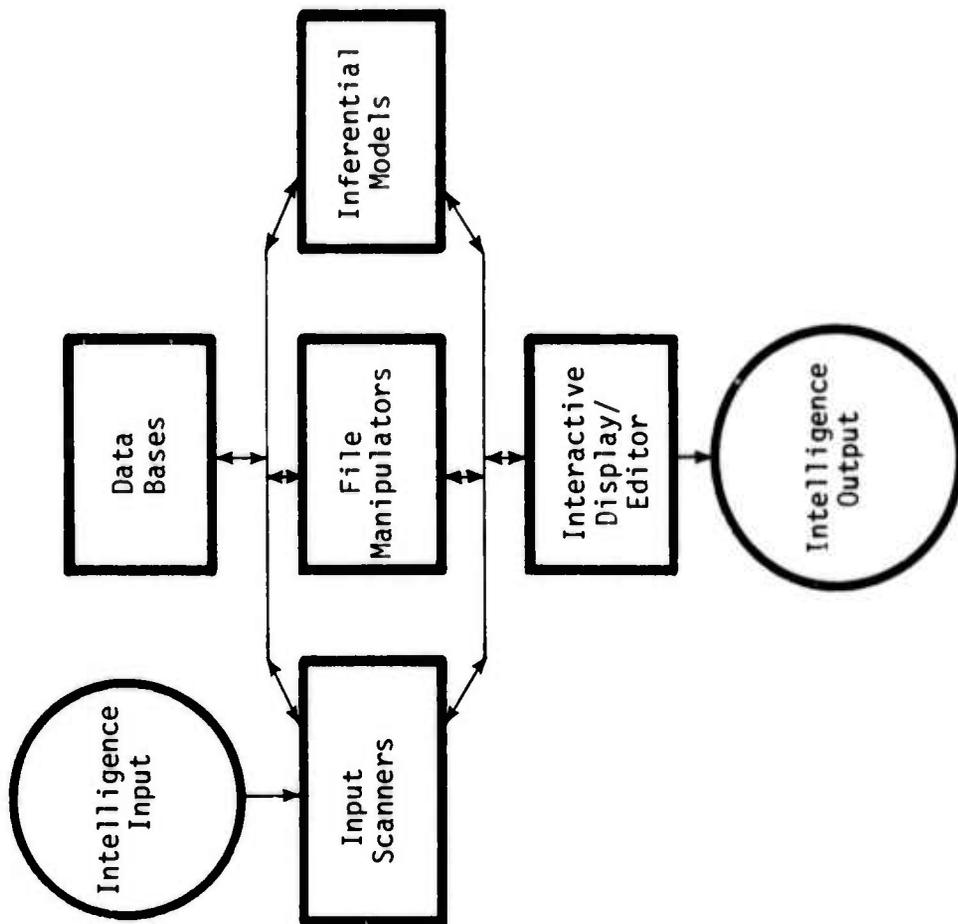


Figure 1. Functional Block Diagram of an Advanced I&W Aid

3. TESTBEDS

Testbed systems involve at least three major components, in addition to the techniques which are to be demonstrated and studied with the system:

1. Study aids which help persons designing and conducting studies to do so efficiently. CCBS techniques such as the laboratory implementation system (LIS) and laboratory measurement systems can be of benefit to the development of special study aids for the current project.
2. Scenario and data base which lend structure and substance to demonstrations prior to full operational implementation. The CCBS work toward developing a technology of scenario development can help to guide scenario and data base preparation under the current contract. A preliminary report on scenarios and data base is being issued simultaneously with this report.
3. Operating systems which provide the basic data-handling capability required to support a demonstration of computer-related techniques. Figure 2 illustrates a simplified sequence of testbed system utilization from systems currently available to full integration of techniques in the I&W operating environment. Emphasis in this sequence is on the different operating systems that might be involved. Initially, our focus is on the use of Cambridge Project and CCBS systems to support unclassified demonstrations on the RADC node of the ARPA network. Depending upon the outcome of initial demonstrations and upon the direction of other RADC computer system programs, a number of options are potentially available for interim testbed systems at RADC. Similarly, a variety of system configurations is possible within user facilities both for testing and eventual full operational implementation. CCBS JOVIAL compiler; META compiler; time-shared routines for analysis, classification, evaluation (TRACE) interpreter; and SMART virtual memory emulator and manager will facilitate transfer of CCBS techniques to other operating systems. Also, Cambridge Project Consistent System conventions, substrate, programs, and documentation will facilitate transfer of Cambridge Project techniques to operating systems other than Multics. However, unavailability of PL-1 compilers is currently seen as a block to facile transfer of much Cambridge Project technology.

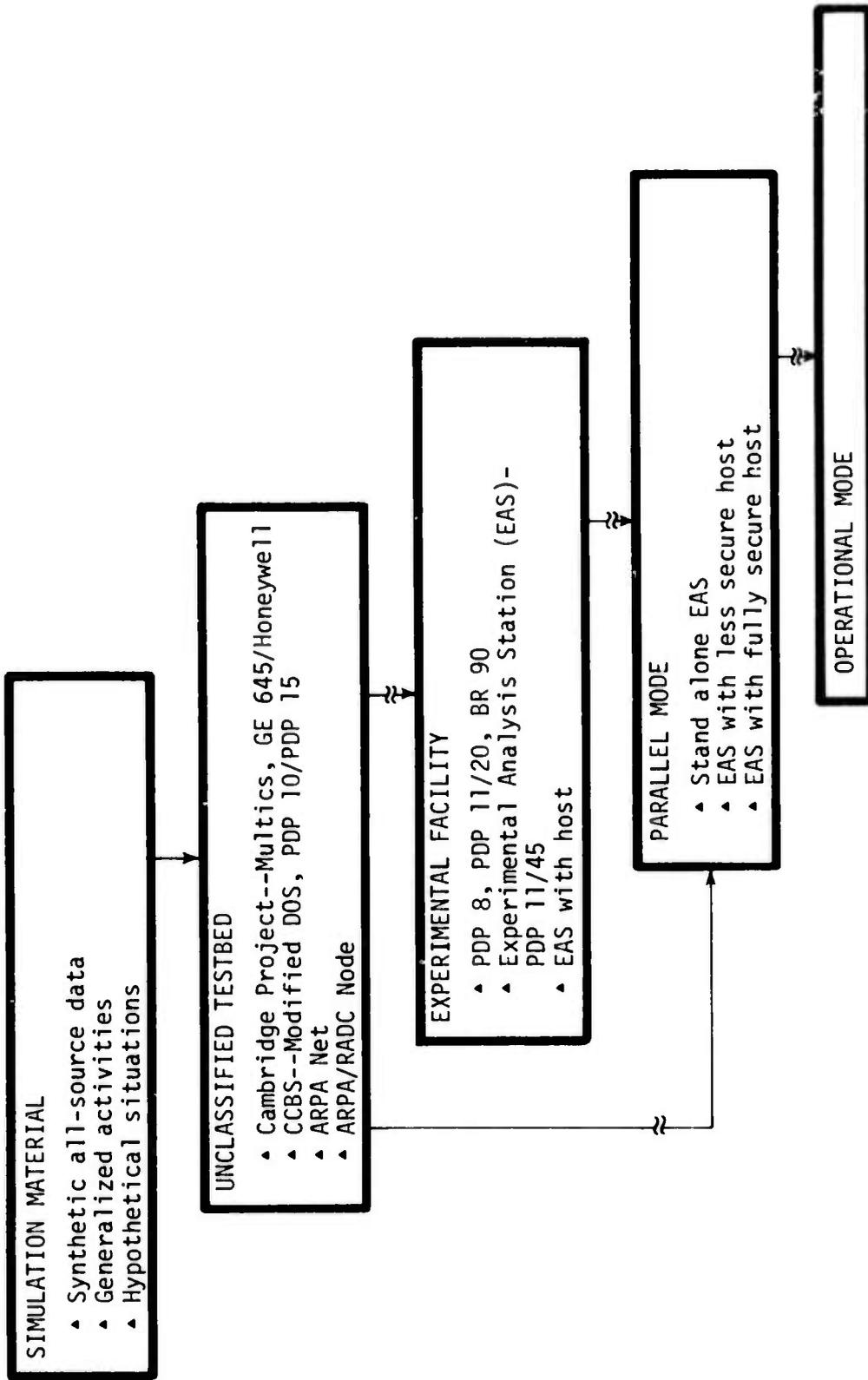


Figure 2. Simplified Testbed System Sequence for Transfer of Advanced I&W Aids

4. INPUT SCANNERS

As illustrated in Figure 3, input scanning can occur at multiple levels. The unique contribution we can make to I&W operations depends very much upon the level of computer-aided scanning.

State-of-the-art techniques which have been demonstrated previously under the Rome Air Development Center Aids to Inference Program and which are currently undergoing operational development involve a combination of recognition of standard terms in fixed format and a simple form of word recognition in free text. The Cambridge Project and CCBS have little that is unique to contribute at these levels, except to provide a consistent base for more sophisticated operations.

Moving to more sophisticated word recognition in free text requires a significant technology of dictionary construction.

Project Diana of the Cambridge Project has made significant progress in the development of techniques for the construction of dictionaries. It is our impression that the Project Diana stemming and word clustering techniques (Quinones, 1972) are close to immediate payoff, and we expect to give them priority.

Project Diana has made significant progress toward automated analysis and coding of relationships among word strings, and in the ability to encode automatically the essential thematic content of text. There is not, however, a set of routines which we will be able to implement immediately and directly. This would put any near-term system demonstrations on a high-risk path if they were dependent on operational effectiveness of parsing and theme encoding techniques. This leads us to adopt an interim strategy which:

1. Minimizes dependency upon full operational parsing and theme encoding capabilities for successful demonstration of an advanced I&W performance aid. This may require accurate forecasting of the outputs and utility of these techniques, even though they are not yet fully operational.
2. Stages the development of operational parsing and theme encoding capabilities through relatively undemanding initial mini-demonstrations on small-scale synthetic data bases.

We view parsing and theme encoding techniques as essentially long-term developmental efforts not suitable for immediate, direct, and general application. In particular, it is necessary that encoding rules developed by Project Diana be validated, augmented, and modified by our consultants on I&W operations. It should also be stressed that the various components of an input scanning capability cannot be considered as operational isolates--there are clear and important interdependencies.

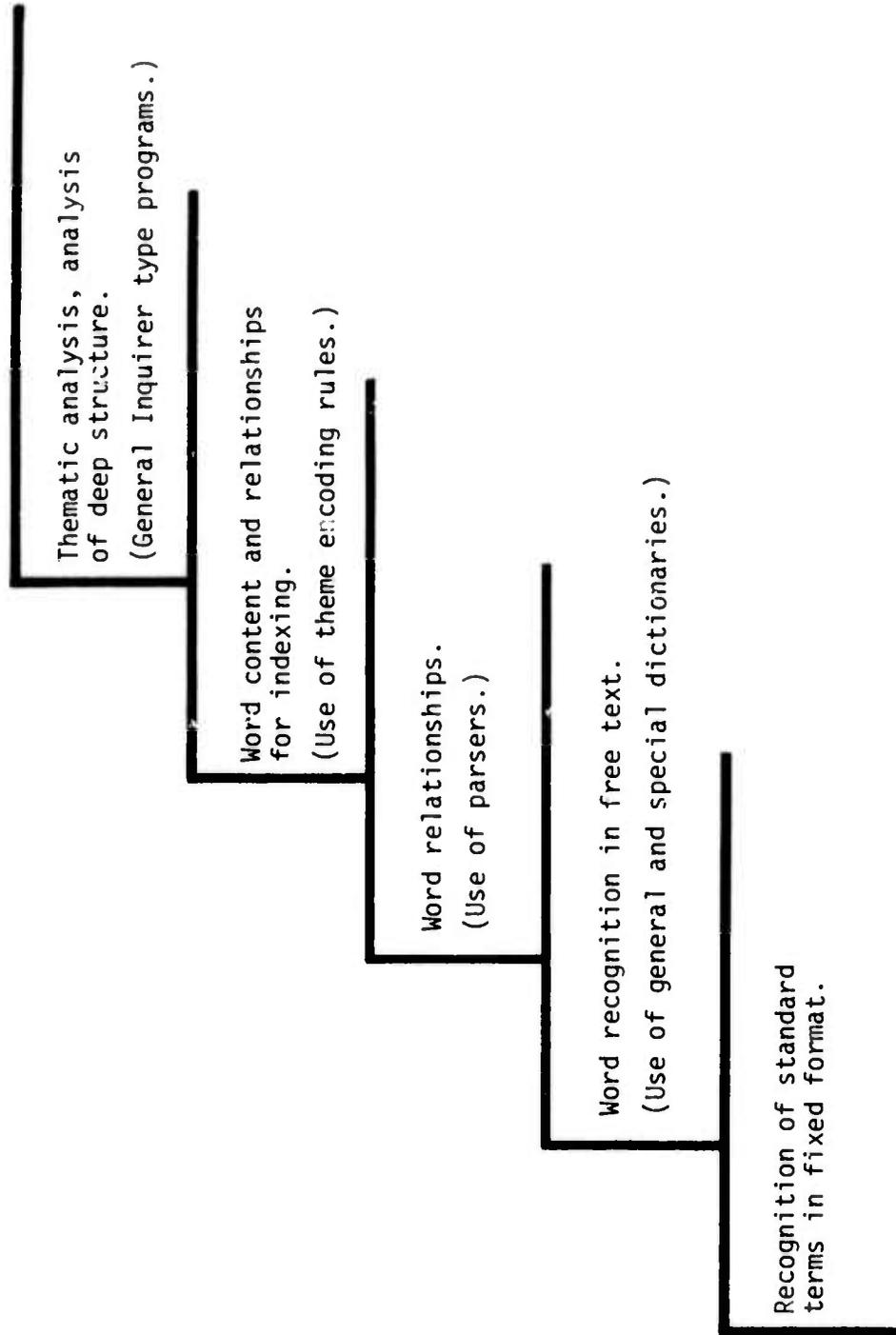


Figure 3. Sample Hierarchy of Input Scanning Techniques

Despite the considerable risks involved in pursuing word scanning, parsing, and theme encoding; they all have reasonable prospects of practical payoff if we restrict our objectives to relatively obvious content recognition and indexing. In contrast, we feel that pursuit of an Inquirer-type general content analyzer does not have reasonable prospects for operational payoff within the scope of the present project.

5. FILE MANIPULATORS

Techniques in this area provide I&W personnel with procedures for interacting with and exploiting their data files. They will emphasize capabilities for querying, reorganizing, and transforming data in the form of word strings, numbers, and graphics, as well as the summarization of the contents of data sets which I&W personnel might judge to be relevant to some given topic. Initial capabilities will have to emphasize word strings and numerical data manipulation, with graphic capabilities (other than flow diagrams and simple charts) being initially limited to more powerful retrieval and correlation with digital data. Later graphic capabilities will, hopefully, involve greatly increased resolution and manipulation of graphics.

The CCBS time-shared routines for analysis, classification, evaluation (TRACE) and Cambridge Project Janus techniques both have promise for the capabilities required in this area. Janus currently appears to be somewhat more amenable for extension to handle word strings, and as such will be the central data retrieval and organizing technique for initial demonstrations. However, TRACE may prove to have capabilities and desirable features lacking in Janus--especially convenient numerical transforms. Janus will be augmented accordingly. WEIS data manipulation techniques may similarly provide a basis for augmenting Janus. Also of interest in this area is the Cambridge Project Admins Mark V, which is a design for a total environment for housing data management and analysis on a dedicated computer. The system includes a procedure language (Admins Language, which is an Algol-like language designed specifically to describe the Admins Mark V file system and data-manipulation algorithms), operating system, disk file system, etc. Admins promises to facilitate the complex file manipulations which are likely to occur in an operational I&W environment, and also has promise in the area of tentative analysis of data sets, acquisition of various forms of raw data, and error detection and correction.

In the realm of file characterization, several techniques are relevant to the recurrent I&W task of relating data which have earlier flowed into the I&W system to some new problem or set of information. This problem involves not only the retrieval of specific items of previously reported information, but also the understanding of multiple streams of data which have come into the system over time. All descriptive statistics and thematic analysis techniques may be relevant here. The CCBS inductive processing aid (IDEA) has some unique potential here in that it supports convenient heuristic partitioning of data sets. The Cambridge Project time-series programs (TSP) seem to be more complete than any time-series analysis routines which CCBS has currently available. CCBS has PRP and the Cambridge Project has similar routines for selecting analytic tools which might be modified to help I&W personnel to select appropriate analytical tools.

6. INFERENCE MODELS

CCBS and the Cambridge Project include the usual spectrum of inferential statistical techniques. Their appropriateness and utility for I&W applications are questionable, however. Most immediately applicable are those which overlap or supplement WEIS techniques, which will be of special utility in helping to define the kinds of hypotheses and assumptions against which I&W personnel may wish to evaluate available data. WEIS projection techniques (McClelland, et al, 1971) include a wide variety of time series and exponential smoothings. Their purposes include a determination of regularities in national interactions, identification of abnormal (especially turns toward conflict) situations, and forecasting states of international relations. WEIS data contain many clues as to the way in which threat is expressed in international interactions. More significantly for our current purposes, however, is the fact that the WEIS Principal Investigator, Dr. Charles A. McClelland, has turned major attention to threat process recognition and analysis. His insights into threat processes should help to guide design of advanced analytical and projection techniques for I&W. WEIS shows such promise that ARPA/HRRO has funded separate investigations with CACI to find DOD application. Synectics is taking care to work with CACI personnel to avoid duplication.

Efficient retrieval, facile data manipulation, and effective data summary can be powerful indirect aids to I&W inference by permitting I&W personnel to focus their attention on the more purely inferential processes. It would also be helpful, however, if additional aids could be provided to help I&W personnel to understand the bases for their estimates of probable future events, definition of the unusualness of a given situation, and detection of threat. Most inferential techniques have not been clearly linked to the realities of I&W processes as yet due to unavailability of the techniques referred to above.

7. DATA BASES

Consideration of data bases will involve the conventions by which media and modes of storage will be defined, as well as the types and characteristics of data base characterization and exploitation aids which will be required in an information-filled environment such as that involved in I&W operations. Of particular interest will be the specification of the indexes and dictionaries required to ensure quick and efficient utilization of various data bases and sections of data bases. Cambridge Project, CCBS and WEIS conventions and results will all be helpful in establishing multiple-access I&W file conventions--but specialized conventions will probably have to be defined.

8. INTERACTIVE DISPLAYS/EDITORS

This complex of capabilities is directed at providing personnel with the capacity for manipulating information and altering it in a way compatible with utilization, reporting, and storage requirements. Both CCBS and the Cambridge Project are heavily oriented toward terminals which permit relatively convenient editing and relatively crude graphics. Our initial emphasis will be on the exploitation of these capabilities. We will also take a longer-range look at graphic research such as that being done for Urban planning at Harvard University, for computer-supported architecture at the University of Utah, and on utilization of the Bunker-Ramo BR-90 graphic terminal.

9. RELATED TECHNOLOGY

There are several quantitative political science efforts which have the potential for contributing to performance aids for I&W personnel. These are the World Event Interactive Survey (WEIS), the Dimensionality of Nations Project at the University of Hawaii under Rudolph J. Rummel, the International Data Archive at the University of Michigan under Raymond Tanter, the World Data Analysis Program at Yale University under Bruce M. Russett, and the Transnational Data Bank at Rochester University under G. V. Barrett. Each of these projects may possibly contribute data sets, models, and analytic techniques to I&W performance aids. Currently, however, our strategy is to move ahead with establishing a basic I&W performance aid structure and exploitation of the Cambridge Project, CCBS, and (to a very limited extent) WEIS. As a first order of business we defer detailed description of potential contributions from these additional projects until a later stage of our work. It is not expected that these efforts will make significant contributions to the project in the form of actual machine aids. However, they can be of significant value in validating the philosophy and concepts of this project.

10. PROJECT PLANS

A series of meetings was held at the Rome, New York offices of Synectics from 10 through 12 April 1973 involving RADC, CCBS, and Cambridge Project as well as Synectics project staff and I&W consultants. Prime purpose of these meetings was to formulate plans for the next six months, within the framework of general plans for the next two and one-half years.

Principal milestones over the remainder of the contemplated period of the project are:

30 September 1973 Demonstration of initial applications potentials to Steering Committee and project staff, using the RADC Node of the ARPA Net.

31 March 1974 Demonstration of a full spectrum of initial techniques having applications potential to Steering Committee and selected I&W personnel, using the RADC Node of the ARPA Net in conjunction with secure RADC experimental facilities.

30 September 1974 Demonstration of transferability of techniques and their ability to handle real data, using RADC experimental facilities at the maximum security level achievable.

31 March 1975 Demonstration of operational capabilities of techniques in test mode at one or more operational sites.

30 June 1975 Demonstration of one or more successful transfers in an operational environment.

30 September 1975 Documentation of the general application potential of advanced techniques for military intelligence.

During the period April-September 1973, project activities will be organized around:

1. A Steering Committee which will provide overall policy guidance, review of recommendations made by the project staff, and guidelines for man/machine interface aspects of technique demonstrations.
2. A testbed system working group that will define and provide necessary interfaces among operating systems, specify data file requirements and media, design basic terminal display capabilities, and provide data input and editing routines.

3. A scenario and data base working group that will provide the data to be operated on and the framework within which the various kinds of data manipulation will be demonstrated.
4. An input processing working group that will translate existing techniques for indexing and content coding input data into a form suitable for demonstrating applicability to I&W requirements.
5. A file manipulation, characterization, and exploitation working group that will translate existing techniques for the analysis of preprocessed data into a form suitable for demonstrating applicability to I&W requirements.

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