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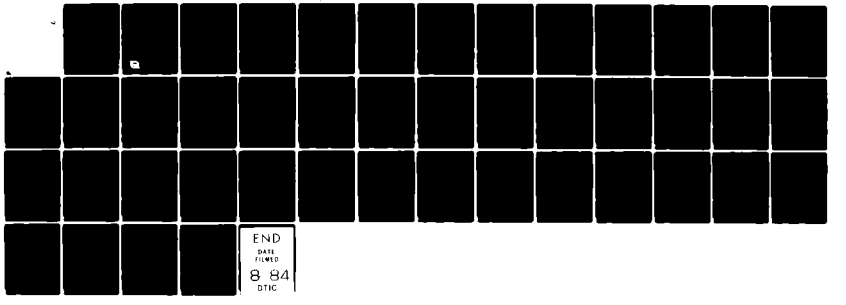

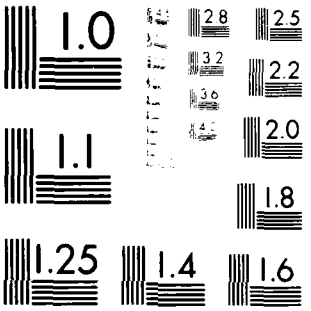

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IDA RECORD DOCUMENT D-51

WIS IMPLEMENTATION STUDY REPORT-- VOLUME I-- MAIN REPORT

Thomas H. Probert, *Project Leader*

October 1, 1983

Prepared for

Office of the Under Secretary of Defense for Research and Engineering

INSTITUTE FOR DEFENSE ANALYSES

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report is the result of a workshop conducted by the Institute for Defense Analyses to develop the functional specifications and estimates of implementation effort for foundation building blocks for Command and Control Systems in WIS. The group concluded that: 1) the development of a modernized WIS incorporating the specified foundation technology building blocks can be accomplished within the time frame proposed, 2) the use of Ada and proposed

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information processing standards are appropriate for use in WIS modernization and are expected to reduce the time required to implement the full system, and 3) it is critical to the success of the WIS modernization that major attention be paid to interface definition and design, system integration and test, and configuration management of the system while under development.

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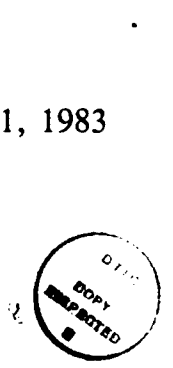
WIS IMPLEMENTATION STUDY REPORT--
VOLUME I--
MAIN REPORT

Thomas H. Probert, *Project Leader*

October 1, 1983



INSTITUTE FOR DEFENSE ANALYSES
1801 N. Beauregard Street, Alexandria, Virginia 22311

Contract MDA 903 79 C 0018
Task T-4-206

FOREWORD

On June 10, 1983, Dr. Richard DeLauer, Under Secretary of Defense for Research and Engineering, approved the final draft of Department of Defense Directive (DoDD) 5000.31, "Computer Programming Language Policy," and circulated it for coordination. This directive establishes Ada as the single common high order language for Defense mission-critical applications. The World-Wide Military Command and Control System (WWMCCS) is specifically identified in supporting documentation to that directive as a mission-critical computer application.

In anticipation of final approval of this directive, the WWMCCS Information System Joint Program Management Office (WIS JPMO) requested the Institute for Defense Analyses to undertake a project to develop the functional specifications and estimates of implementation effort for foundation building blocks for Command and Control Systems. These software capabilities will be used to support the operation of the WIS and will be developed in Ada.

These eleven key foundation building blocks have been divided into two groups: near-term areas for which the specified packages will be operational by January 1986 and mid-term areas for which the specified packages would be operational by January 1989. Near-term areas are characterized by encompassing mature technology that is currently embodied in operational systems. Development of packages for these areas should capitalize on existing software requirement definitions and design specifications. Mid-term areas are characterized as or near the current state of the art and will require significant requirements analysis, architecture and design specification activities.

The participants in this analysis, specification and planning study were chosen according to three criteria: they are all recognized experts in respective key technical areas, they all have had direct implementation experience, and they were all chosen with regard to broad representation of the technical and commercial community. Background information for these people can be found in Volume II of this Record Document.

The study was performed in four phases. First, individual experts were selected for their recognized expertise in each of the foundation areas. One expert in each area, working independently, was tasked to produce a working paper describing the state of the art, discussing the technical issues, and venturing predictions for possible extensions to that state of the art. Each report presents an overview, a discussion of functional requirements for the system or for a set of packages for the system, case studies dealing with similar existing systems, analysis of the information including cost and schedule estimates, and conclusions. In the mid-term areas the case studies were replaced by discussion of the state of the art, the state of practice, and forecasts of new products. These reports were collected and distributed to the larger group of selected experts according to their expertise as preparation for the cluster workshops. These reports can be found in Volume III of this report.

In the second phase, four "cluster" workshops were conducted to perform similar analysis for each foundation area. These workshops addressed these foundation areas grouped according to technical similarity and dependence. Each cluster workshop used the submitted expert assessment as a baseline and point of departure. The goal of these cluster workshops was to assess the content of the reports and make recommendations regarding consistency, bias, level of effort, etc., such that the contents of these reports and the workshops could be merged into a final document.

The third phase entailed the analysis of all the cluster workshop reports in a meeting of the cluster chairpersons. This was conducted to eliminate areas of redundancy and assess the effort required to integrate all the foundation areas into a coherent system description and estimate of total effort. These conclusions can be found in the Executive Summary, Volume I of this report.

Finally, this Record Document has been prepared by the IDA project management, cluster chairpersons and Computer and Software Engineering Division technical staff.

Thomas H. Probert
Project Leader

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Cluster IV Papers --

EXECUTIVE SUMMARY

The discussions of the cluster workshops as well as the reports submitted by the identified experts were conducted and prepared as individual components of a large system. Obviously the individual conclusions of these reports are biased in two ways. First, they do not account for effort required to define interfaces between components, integrate and test the full system, or for continued enhancement and configuration management. Second, each group of technical experts was involved in sizing software in a closely related technical area as opposed to maintaining the larger system view.

A second panel was convened to evaluate the results of the cluster workshops. This panel was tasked to adjust the schedule and cost estimates of these clusters to reflect actual interface definition and control, integration and testing, and configuration management and enhancement. The general conclusions and adjusted schedule and time are presented in the following discussion.

A. **The Development of a Modernized WIS Incorporating The Specified Foundation Technology Building Blocks Can be Accomplished Within the Time Frame Proposed**

B. **The Use of Ada and Proposed Information Processing Standards Are Appropriate for Use in WIS Modernization and Are Expected To Reduce The Time Required to Implement the Full System**

C. **It Is Critical to the Success of the WIS Modernization That Major Attention Be Paid to Interface Definition and Design, System Integration and Test and Configuration Management of the System While Under Development. This is Anticipated for the Major Area of Effort.**

The revised time and effort schedule is:

BASE EFFORT

	EFFORT BY YEAR IN MAN YEARS				
FOUNDATION TECHNOLOGY	84	85	86	87	88
Network Protocols	25	40	50	25	10
Graphics Protocols	25	35	35	20	
Text Processing	15	10			
Prediction & Optimize Tools	25	35	25	25	15
Database Tools	15	19	18	6	3
Command Language	10	14			
Military Message	10	15	10	5	
Common Operating System	50	70	45	10	
Conversion Aids	26	10	10		
Software Design Tools	18	10	10		
EMERGING TECHNOLOGY					
Secure Teleconferencing	10	10	10	3	
Solution Methodologies	35	56	83	105	59
TOTAL BASE EFFORT	264	324	296	199	87

TOTAL EFFORT

	84	85	86	87	88
BASE EFFORT	264	324	296	199	87
SYSTEM ARCHITECT & INTEGRATION	5	5	5	5	5
ADMINISTRATION, CONF. MGMT. (.1 Multiplier)	27	32	30	20	9
TOTAL EFFORT	296	361	331	224	101
EQUIPMENT ($M)		3.5	4.5	2.5	

CLUSTER I:

STRUCTURED INFORMATION MANAGEMENT AND PLANNING SYSTEMS

WIS IMPLEMENTATION STUDY

CLUSTER I -- Structured Information Management and Analysis

ATTENDEES

SEPTEMBER 22-23, 1983

Carlson, Mr. William E. *	Intermetrics, Inc.
Crafts, Mr. Ralph E. *	Intellimac, Inc.
Fogel, Dr. Lawrence J. *	Titan Systems, Inc.
Graulich, Mr. Mark G. *	Vector Research, Inc.
Greene, Col Joseph	WIS/JPMO
Luenberger, Prof. David G. *	Stanford University
Ries, Dr. Daniel R. *	Computer Corporation of America
Schill, John	Naval Ocean Systems Center
Shrier, Dr. Stefan *	System Planning Corp.
Smeaton, Roger*	Naval Ocean Systems Center
Trocki, Mr. Martin C. *	Intermetrics, Inc.
Tse, Prof. Edison T.S. *	Stanford University
Wiederhold, Dr. Gio C.M. *	Stanford University
Whitaker, Col William	WIS/JPMO

*Background information on these people can be found in Volume II of this Record Document.

CLUSTER I:

STRUCTURED INFORMATION MANAGEMENT AND PLANNING SYSTEMS

The Cluster I meeting was held on 22-23 September 1983 to discuss technology alternatives available to WIS in the areas of structured information management and planning systems. The discussion focused on providing an integrated system of tools for operational planning. These tools would be used to monitor the status of resources and forces, to plan and schedule operations, and to monitor the execution of plans. Foundation technologies which support these activities include data management, statistical analysis, mathematical programming, simulation, and artificial intelligence. Implementation of the planning system assumes a baseline of information processing, computer communications and teleconferencing capabilities as discussed in Study Clusters II, III and IV.

The overall conclusion is that the interfaces to databases will be the foundation on which all WWMCCS planning applications are implemented. Specification, implementation, validation and configuration management of the data storage and retrieval tools is an extremely critical task on which the overall success of the WIS Program depends.

DARPA and the Navy are funding an exploratory effort to develop a database management system in Ada. That system, called ADAPLEX, shows a sound technical direction. It consolidates the best data management technology embodied in commercial products and utilizes the results of data base research at Stanford, Berkeley, and elsewhere. This effort should be accelerated and reinforced to produce a baseline capability within 18 months.

Study participants decided that current generation mathematical programming libraries, statistical packages and simulation techniques could provide powerful capabilities for the WIS. A high priority effort is needed to recode existing algorithms in Ada. Especially important will be the development of standard interface conventions that allow the planning tools to be applied in any combination and in any order. It is also recommended that intelligent systems technology be used to create a flexible and easy-to-use interface to the planning system.

A set of benchmark planning scenarios needs to be defined in coordination with operational personnel. These scenarios will provide a basis for judging the appropriateness of the tools and interfaces which are developed. Hence, they will be the primary criteria for validating that the data storage, retrieval, analysis and optimization capabilities that are developed provide a viable precursor for the next generation WWMCCS Information System.

HIGHLIGHTS OF DISCUSSION

Study participants came from diverse backgrounds spanning a variety of commercial and military planning applications, as well as the foundation computer technologies.

Two planning systems developed by participants set an example for the future WIS system. One is the "Interactive Planning and Programming System" developed by Vector Research and used for both R&DCOM personnel planning and contingency force analysis. The other is the "KNOBS-TEMPLAR" system developed as a prototype for Tactical Air Control Centers. These systems have a similar structure: a database as the source of the facts that drive the planning process, a collection of prediction and optimization aids that are applied in various ways depending on the particular problem to be solved, and a planner's assistant module that helps the user configure the data and models and interpret the results.

The technology for building planner's assistant software is embryonic. Database technology is mature. Hence, database capabilities can be developed and stabilized early in the system life cycle. Intelligent software to guide the planning process should evolve over several years through multiple releases that provide incrementally enhanced capabilities. There can be multiple implementations to meet unique needs of particular applications.

An adequate validation of the framework architecture for future WWMCCS planning systems will require at least five sites. This conclusion is based on various studies of organizational behavior that show that special cases dominate scenarios involving four or fewer nodes in a decision structure. Hence, the precursor software should be validated in a variety of scenarios involving seven plus or minus two participating teams.

RECOMMENDED PLAN

Three areas of activity are proposed to develop and validate the foundation tools and technologies for planning. Because the planning tools run on top of other baseline technologies, including operating systems, network protocols, user interface tools and teleconferencing, the benchmark planning scenarios can be used to validate the complete set of precursor technologies.

The proposed plan is to immediately start the development of required foundation tools. At the same time, during the first year, a stratification of WIS-relevant planning scenarios will be accomplished. This stratification will be used to baseline current and proposed planning scenarios and to get C^2 community feedback.

The benchmark planning applications and scenarios will be developed during the second and third years, and the most promising combinations of tools selected for release to Beta test operations.

The database foundations area will be target for an initial capability in 18 months and a complete capability in 30 months. Special requirements on the DBMS include a system-wide standard for representations of the date and time, the ability to store data for multiple (possibly inconsistent) future scenarios, careful maintenance of an audit trail on missing and estimated data, and fault tolerance.

The National Bureau of Standards catalog of mathematical programming and statistical packages is one source of information on available algorithms and software. A complete library of the most popular algorithms should be acquired

within the next 24 months. Interfaces should be refined to provide maximal interoperability.

The precursor demonstrations and validation will require a complete context of hardware, software and communications capabilities that model the next generation WWMCCS environment. Included must be command information management aids for text and graphics, teleconferencing, electronic mail, software development, configuration management, and executive planning aids. It must be a secure environment so real data can be used. Care must be given to addressing all levels of command within the WWMCCS charter, from the NMCC to the C^2 systems of the Services and Component Commands. This approach to validation is termed "Solution Methodologies", because it deals with the full range of problems that must be solved to meet the needs of future WWMCCS users.

COST AND SCHEDULE

DATABASE AND MATHEMATICAL TOOLS (1986)

	1	2	3	4	5
DATA FOUNDATION					
- Multiprocessor Capability	3	3	2		
- Modularize & Productize ADAPLEX*	6	10	10	5	2
- Ada Environment Integration	3	3	3	1	1
- Configuration Management	1	1	-	-	-**
- Directory Service	2	2	-	-	-**
STATISTICAL OR PACKAGES	15	15	5	5	5
EXPERT SYSTEMS INTERFACE	10	20	20	20	10
TOTAL STAFF YEARS	40	54	40	31	18

* Assumes DARPA & Navy Funding for ADAPLEX
** Included in Row 3

EMERGING C² Ada SOFTWARE PRECURSOR (1989)

TASKS	1	2	3	4	5
BUILDING FOUNDATION PACKAGES	See Other Cluster Summaries				
EXPERIMENTAL DESIGN AND ANALYSIS --HYPOTH DBMS HISTORY	20	5	5	5	5
ARCHITECTURE SPEC & VALIDATION	10	10	3	3	3
EXP CONTROL & OPS INCLUDING HDWR OPS	3	7	10	10	10
LOAD FOUNDATION SOFTWARE, V&V		2	3	3	1
PLANNING TOOLS & PILOT *3-5 PROJECTS, 5-10* PEOPLE INCLUDING		25	50	70	30
USER TRAINING, SUPPORT & DOCUMENTATION	2	7	12	14	10
TOTAL TECH STAFF YEARS	35	56	83	105	59
HARDWARE @ $25/K USER ($2.5M) & MAINFRAME/OR NUMBER CRUNCHER		$1M	$2.5M	$1M	$200K
COMMUNICATIONS ($)		$1M	$1M	$1M	$1M

CLUSTER II:

USER INTERFACE AND PAPER IMAGE MANAGEMENT

WIS IMPLEMENTATION STUDY

CLUSTER II -- User Interface and "Paper Image" Management

ATTENDEES

SEPTEMBER 22-23, 1983

Cummings, Mr. Clifford I. *	Jet Propulsion Laboratory
Dempsey, Mr. James B. *	GTE R&D
Harbaugh, Dr. Samuel S. *	Harris Corp.
Harrington, Mr. Richard J. *	Software A&E, Inc.
Hogan, Mr. Thomas J. *	INCO, Inc.
Kaczmarek, Dr. Thomas S. *	USC/ISI
Power, Dr. Daniel J. *	University of Maryland
Sapp, Mr. John W. *	Software A&E, Inc.
Shelley, Mr. Stephen H. *	Intermetrics, Inc.
Sykes, Mr. Wendell G. *	Arthur D. Little, Inc.
Weidner, Mr. Karl J. *	INCO, Inc.
Willis, Mr. Paul A. *	Intellimac, Inc.

*Background information on these people can be found in Volume II of this Record Document.

CLUSTER II:

USER INTERFACE AND PAPER IMAGE MANAGEMENT

The topic of the Cluster II workshop session was "User Interface and Paper Image Management." All human or end user interfaces are represented in this cluster excluding direct applications. The session was partitioned into five areas, each described below.

TEXT PROCESSING PROTOCOLS

The objective of the text processing foundation technology is to develop a fully portable software capability for processing text and documents. This capability incorporates all "standard" features of existing text processing systems. In addition, optional features such as color graphics and text and digital voice and image manipulation were considered highly desirable. These optional features are existing technology but are not generally available outside the experimental or commercial prototype area.

HIGHLIGHTS OF THE DISCUSSION

The basis for the discussion was the report prepared by Newburyport Computer Associates, Inc., entitled "Text Processing Systems." The present state of the art is more advanced than mere text processing. The concept of full document management was considered a realistic near-term goal. This differs from text processing in that a hierarchy of capability exists with text processing as the low end, word processing as an intermediate, and document management as the high end of the technology. Document management includes color graphics and text capability, use of multiple fonts, and preservation of graphical representation within a document. Examples of existing systems incorporating several, but not all, of these features include LISA Professional Computer developed by Apple Computer and the STAR Executive Workstation developed by XEROX.

Additional features recommended by the group include a Computer Aided Instruction (CAI) capability providing online instruction in the use and capabilities of the system as well as the ability to define a multi-level security classification as a property of each document. Some level of cartographic representation and manipulation is also highly useful in the WIS context.

The group raised the point that successful development within schedule and cost of a high quality document processing system is dependent upon the concurrent and successful development of a superior graphics facility. In fact, it would be difficult, if not impossible, to develop either without accommodating such interdependency. A second point of concern is the maintenance of acceptable performance particularly on multi-user systems. A high level of performance is considered essential to the system acceptance.

RECOMMENDED PLAN

The recommended plan for development of a document management facility is based on the use of existing and draft standards for text processing and graphics. Specifically the draft standard "Computer Languages for the Interchange and Processing of Text (CLIPT)" and "Graphical Kernel System (GKS)" were mentioned. The document management system would be designed and implemented in two phases.

SCHEDULE AND COST

First, the standard document processor is developed. Requirements definition, design and implementation should require no more than 5 man years of effort and be completed in 12 months. During this first phase requirements analysis and design are being performed for the implementation of the enhanced system. Requirements analysis and design are expected to require 10 man years during this period. Implementation of the enhanced system is expected to require 10 man years and be completed within 24 months from the start of work. The total effort for this foundation building block is estimated at 15 man years in the first 12 months and 10 man years in the following 12 months. These results are summarized in the following table:

SYSTEM	START	END	EFFORT
Implement Basic	**1/84**	**1/85**	**5 man yrs.**
Enhanced Requirements	**1/84**	**1/85**	**10 man yrs.**
Implement	**1/85**	**1/86**	**10 man yrs.**
	2 years		**25 man yrs.**

GRAPHICS PROTOCOLS

The objective of the graphics building block is to provide a high quality graphics support software toolset for report generation, presentation graphics and support of the general human interface to WIS. In addition, graphics capabilities will be employed in decision support systems, teleconferencing, and cartographic applications.

HIGHLIGHTS OF THE DISCUSSION

The baseline document for discussion was "Standards Graphics Packages for Command and Control," by William E. Carlson and Stephen Shelley, both of Intermetrics, Inc. The group generally agreed with the notion of using existing or proposed graphics standards in the development of the graphics capability. It is expected that using standards such as the proposed ISO/DIS 7942 Graphical Kernel System (GKS), the proposed Ada binding for GKS submitted to ANSI X3 for consideration, the North American Presentation Level Protocol (T500-X3L2.1/82-72), and the Programmers Hierarchical Interactive Graphics Standard (PHIGS) will save

considerable requirements analysis and specification as well as design costs. Partial implementations of all of these are currently available or under way. In fact, the Harris Corp. presented a detailed discussion of a GKS to Ada binding they have defined and presented to ANSI for standardization. This binding has already been partially implemented.

The group felt that additional features would be required including development of a virtual device metafile (VDM) for the portability of stored graphical representations; 3-dimensional graphical display development software tools; some level of animation (for battlefield or other tactical display); general graphics tools; and support for terminal/user interface "windowing" in support of the forms and menu requirement. Further requirements analysis must be done in this area. Finally, a highly desirable enhancement for use in text processing and message handling is the development of a high quality multi-media presentation graphics toolset. Many of these capabilities exist but none has been fully integrated into a single hardware/software implementation. For this reason the group generally felt optimistic that a near-term capability was certainly attainable. However, further work would need to be done in the mid-term for enhancement.

The group recommended, however, because of the high performance requirement, hardware dependence, and "visibility of graphics tools in the human interface" that great care be taken in maintaining performance and in integrating the capability into WIS.

RECOMMENDED PLAN

The development of the graphics toolset should proceed in two phases. First, develop and implement a "baseline" graphics capability using existing GKS/Ada binding and very-near term graphics technology. Second, while performing the first phase, begin requirements and design analysis for the second phase. The second phase will be to add enhancements such as metafile portable storage, animation and 3-D graphics tools. In parallel with this second phase, the presentation graphics capability would be developed. The second phase products would be mid-term and delivered in increments through 1987.

SCHEDULE AND COST

During the first phase 10 man years would be expended over the first 24 months to produce the baseline graphics capability. In the following 24 months 13 man years of effort would be needed to implement the enhancements discussed above. This schedule and sizing was estimated assuming requirements specifications were known and interfaces to other portions of the system were defined, and that all necessary utilities (upon which 80 percent or more of the code would depend) were available through the operating system. This totals 23 man years over 48 months. The following table summarizes these results.

SYSTEM	START	END	EFFORT
Basic	**1/84**	**1/86**	**10 man yrs.**
Enhanced	**1/86**	**1/88**	**13 man yrs.**
	4 years		**23 man years**

COMMON COMMAND LANGUAGE

The objective of defining and developing a common command language across all applications is to provide a single common interface between users and the underlying operating system utilities. This results in several benefits. First, it provides all users with a common view of the system structure. Second, it promotes increased use of application specific control procedures which are by definition system portable. Finally, it allows the application of modern high order programming practices to command language programs.

HIGHLIGHTS OF THE DISCUSSION

The baseline document for the discussion was "Command Language Design" by Dr. Thomas Kaczmarek of USC/Information Sciences Institute. The paper discusses the present state of practice with emphasis on the use of forms, menus and icons as well as other graphics forms for use in the command language.

Another paper, "Distributed Software Engineering Control Process, Task 2: Analysis and Functional Description, Software Engineering Analysis," presented by J. Dempsey from GTE Network Systems R&D described the use of "full" Ada as a command language. Various models were debated during the subsequent discussion. The model emerging as particularly interesting is based upon the use of a three-layer hierarchy wherein the user has access to the top and middle layers. The top layer is composed of application specific command languages as very high level language programs. These are used in application specific domains where knowledge of the underlying Ada command language would not be necessary, perhaps even confusing and counterproductive. The middle layer contains the actual command language, Ada. This can be used as either single line parameterized function or procedure calls or composed into "Ada programs" to be interpreted much as EXEC or Job Control Procedures are currently used. Finally, the underlying bottom layer is composed of libraries of Ada packages containing functions used in the middle and top layers.

The implementation of this concept would not be difficult as the proposed definition in the GTE paper appears sound. Existing Ada interpreter/translator technology is sufficiently available to promote the concept. However, the dependence upon interface definition to all other user-accessible areas and the availability of support graphics and text utilities are a potential pitfall.

RECOMMENDED PLAN

The technology and most of the Ada software already exist or are very near-term capabilities. Therefore the primary focus is on acquisition, modification and testing rather than on new development. It is expected that within 18 months from start of work a functional Ada command language interpreter could be developed using existing compiler front end technology.

SCHEDULE AND COST

The tasks for the development of an Ada command language interpreter are:

1. Develop the interpreter (5 man years over 1 year)

2. Provide CAI, enhancements, string handling, and focus enhancements (18 man years over 1 year).

The proposed schedule is:

TASK	START	END	EFFORT
1	1/84	1/85	5 man years
2	6/84	6/85	18 man years
TOTALS		1.5 years	23 man years

MILITARY MESSAGE PROCESSING

The objective of this technical area is to provide reliable and secure movement of military message traffic as well as tools necessary to review, disseminate and coordinate messages within a site. The benefits of an integrated message handling facility rest primarily upon two factors. First, as an integrated tool, the message handling facility can utilize other software tools such as the standard system text processor, etc., for message development. Second, the time required to process message traffic will be reduced if the facility is integrated into the WIS as opposed to another application facility.

HIGHLIGHTS OF THE DISCUSSION

The baseline paper for discussion was "Military Message Processing" by INCO, Inc. The paper described an existing military message handling system designed and implemented for the Air Force Intelligence Service. The group felt that other facilities such as text processing and graphics support would make the development of such a capability reasonably easy. It was pointed out that the security requirements and design would not be at all trivial and the test and integration period might be extensive. In addition, the dependence of the full secure facility on other WIS facilities implies development late in cycle.

Additional features described by the group were local and selective encryption of messages in addition to transmission security, the ability to verify that messages had been received, interrupt notification of message status by message priority, and the ability to prioritize messages.

RECOMMENDED PLAN

The recommended plan of development and implementation is to begin to design and develop the system in one phase. The urge to implement in two phases, where a "standard" capability is developed and then enhanced, should be resisted. User base development and security dictate that the system have adequate early and uninterrupted service. Therefore the plan is to design and specify in Ada, implement for Beta test, and finally release the full enhanced system.

SCHEDULE AND COST

Given that appropriate tools, text processing, etc., exist, then the following schedule and effort are proposed:

	START	END	EFFORT
Requirements Specification and Design	**1/84**	**6/84**	**4 man yrs.**
Implement and Test	**6/84**	**1/86**	**8 man yrs.**
	2 years		**12 man years**

CLUSTER III:

SECURE TELECONFERENCING AND NETWORKING

WIS IMPLEMENTATION STUDY

CLUSTER III -- Information Exchange

ATTENDEES

SEPTEMBER 22-23, 1983

Anderson, Mr. John W. *	Sigma Associates
Bail, Dr. William G. *	Intermetrics, Inc.
Evans, Mr. Albert J, Jr. *	INCO, Inc.
Ferrentino, Mr. Andrew B. *	Software A&E, Inc.
Fox, Mr. Joseph M. *	Software A&E, Inc.
Gurwitz, Mr. Robert F. *	Bolt, Beranek & Newman, Inc.
Joseph, Dr. Robert E.*	Titan Systems, Inc.
Klein, Dr. Stanley A. *	ORI, Inc.
Larsen, Dr. Robert E. *	Optimization Technology, Inc.
Magliato, Mr. Frank J. *	Sigma Associates
Miller, Mr. Richard H. *	Telematics International
Priven, Mr. Lewis D. *	Satellite Business Systems

*Background information on these people can be found in Volume II of this Record Document.

CLUSTER III:

SECURE TELECONFERENCING AND NETWORKING

The topics of the Cluster III session, Thursday and Friday, September 22, 23, 1983, were Secure Teleconferencing and Networking. Each of the areas will be covered in a separate section of the following discussion.

SECURE TELECONFERENCING

OVERVIEW

The objective of secure teleconferencing is to realize in the WWMCCS environment some of the benefits being achieved by the industrial uses of such technology. The original justification for teleconferencing was reduced travel time and costs, but industry now feels that there are significant benefits in the use of teleconferencing because of faster and better discussions, better person-to-person communications, and increased individual productivity.

HIGHLIGHTS OF THE DISCUSSION

The basis for discussion was the Sigma Associates paper on "Secure Multi-Media Conferencing," and a list of questions generated at the beginning of the meeting. Three forms of teleconferencing projects were discussed: motion video conferencing --"meetings"; audio teleconferencing with graphic and database augmentation -- "meetings"; and multi-function multi-media workstation conferencing -- "terminal user". In summary, it was felt that all of these forms had a place in the WIS environment, but that at present the participants did not understand where would be the proper cost-effective applications.

Two of the forms of conferencing, audio conference with graphic and database access augmentation and motion video teleconferencing, involve meeting room environments. The third form involves conferencing among multi-function/multi-media workstations operating in the WIS work environment. It was felt that the motion video teleconferencing should be extended to include single person, commander office to commander office type of system previously developed under DARPA auspices.

The consensus of the cluster members was that all three forms were within the technology window of WIS, that there were undoubtedly applications of each within WIS, but without proper prototyping, the cost effective application of each might not be achieved. The method and schedule proposed therefore emphasize pilot installations, carefully selected locations, and limited introductions into an operational environment.

RECOMMENDED PLAN

Some criteria for selection of the organization and location were developed and agreed to. It should be emphasized that it is absolutely critical to the success of these pilots that performance metrics and the process for measurement of the effectiveness of these systems should be established prior to the start of the pilot programs. The motion video conferencing pilot should run at least two years and possibly three years so that at least one change of commanders can be observed and the "social acceptance" of this media tested.

The plan involves three phases: a requirements and planning phase, procurement and implementation phase, and pilot and evaluation phase. Because the technology is fairly mature but still developing, the equipment should be off the shelf; assembled and operated by a "system" house; and improved as technology improves if this does not impact the prototype. The prototypes should involve two motion video rooms with two commander offices, two to four audio-conferencing rooms and sufficient multi-media workstations to capture a reasonable interacting group of workers. Security considerations and the effect of crypto requirements on these teleconferencing prototypes is one of the concerns that the cluster members were not able to assess and which needs to be studied during the prototype. The cost of cryptographic gear is not included in the cost estimates below.

SCHEDULE AND COST

	ELAPSED TIME	MANPOWER
Requirements/Plan	**9 mos.**	**2.1 man yrs.**
Procurement/Installation		
MMWS & Audio	**1.0 yr.**	**2.0 man yrs.**
Motion Video	**1.5 yr.**	**1.25 man yrs.**
Pilot		
MMWS & Audio	**1.5 yr.**	**2.0 man yrs.**
Motion Video	**2/3 yr.**	**1.5 man yrs.**
Evaluation	**6 mos.**	**.75 man yrs.**

HARDWARE AND SOFTWARE INSTALLATION COSTS

	PROTOTYPE	1990 OPERATIONAL
Motion Video	$300-500K/Room	$150-250K/Room
Audio	$100-200K/Room	$50-100K/Room
MMWS	$25K/Station	$2-10K/Station

OPERATIONAL COSTS

$300-600K/Year

NETWORKING

HIGHLIGHTS OF THE DISCUSSION

The report submitted by McQuillan Consulting was used as a baseline for the estimates. It was determined that the assumptions of the report on which the estimate relied were overly restrictive and in some cases inappropriate for a WWMCCS report. It was the opinion of the group that practical Ada implementations of TCP/IP protocols should be a near-term objective. These early Ada implementations, which will have to be done within existing operating systems and will involve some performance timing, will result in the development of a standard portable Ada implementation for the productive WIS environment.

RECOMMENDED PLAN

The group identified five separate phases or project tracks which should be initiated simultaneously.

The five-phase plan is based upon the assumption that the implementation of the TCP/IP and associated protocols can and should be initiated immediately. However, because the protocol itself is rather new and because formal specification of the protocol is not yet available, a parallel effort regarding specification, verification, and potential use of the protocol should also be mounted immediately.

Phase 0 is to be conducted in parallel with the Base Implementation, Phase 1. The objectives are the formal specification of interfaces for RTCP/IP and associated application protocols (SMTP, FTP, and TELNET) to be used by implementors. In addition, this phase should result in the development of a more generalizable formal specification mechanism and protocol verification mechanism to be used for extensions of the protocol suite (i.e., beyond TCP/IP).

In concert with the development of specification and verification tools, the effort in this phase should be directed toward a clear definition of the environments in which the network components of WWMCCS will operate. This would include projections of the equipment and mix of uses to which the system will be subjected.

Phase 1 is the major near-term effort. The objectives of this phase are to complete operational implementations of the suite of network/transport protocols, i.e., TCP/IP, UDP (User Datagram Protocol), ICMP, and to complete operational implementations of the currently defined suite of applications protocols, i.e., SMTP, FTP, and TELNET.

We assume that for these early installations between 70 and 80 percent of the Ada code will be portable without modification.

Phase 2 involves the implementation of a more complete suite of user protocols than is currently defined for WWMCCS. Not yet defined are a number of application protocols which will require research, specification and implementation." Although an incomplete list, the following protocols should be investigated immediately, with the objective of initiating implementation efforts at approximately that time when the Base Implementation phase is winding down:

- o Virtual Terminal Protocol
- o Directory Service
- o Document Content/Document Interchange Protocols
- o Distributed Database Protocols
- o Remote Procedure Protocol
- o Others yet to be identified.

Although the WWMCCS/WIS effort is primarily concerned with the development of network services conforming to the DoD/DCA network standards, the operating environment of WIS will of necessity require the interworking of WIS with networks and hosts conforming to other protocols. (For example, the need to interwork with European Postal Telephone and Telegraph (PTT) services or the need to interwork at the applications level with host computers not fully integrated into the WIS.) Phase 3, therefore, involves the development of facilities and services by which the WWMCCS system can interwork with "foreign" protocols on both the network/transport levels and the applications levels. This effort must begin by establishing a research and tracking effort to identify those protocols with which the WIS must interwork. The primary target protocols of interest are those currently under development by CCITT, ISO, ANSI, NBS and ECMA and possibly the proprietary protocols being developed by commercial interests, such as IBM's SNA.

Phase 4 establishes an effort to focus on the development of "adaptive" Ada implementations. The objective here is to develop implementations which, under program control, can adapt to the various environmental factors under which the package operates in order to increase portability. The implementations should be designed to adapt in a "real-time" manner to the conditions of the network and the traffic loads placed on the network.

The objectives of this phase are two-fold: to use the results of Phase 0 definitions of environment to prepare for major portability concerns, and to use the monitoring and control elements identified and developed in Phase 1 as the basis

on which the implementation can adapt to the load placed on the network to meet pre-defined performance requirements.

SCHEDULE AND COST

The proposed schedule and costs are presented in the following table:

	ELAPSED TIME	EFFORT
Phase 0 -- Preimplementation and specification --		
Interface specification	6 mos.	0.75 man yrs.
Environment specification	3-4 yrs.	2.00 man yrs.
Formal specification & verification	1.5 yrs.	3.00 man yrs.
Phase 1 -- Base Implementation --		
TCP/IP, ICMP, UDP, MSTP, FTP, TELNET	1.5 yrs.	5.00 man yrs.
Documentation & recordkeeping	2.0 yrs.	5.00 man yrs.
Tools and Implementation Tuning	1.0 yr.	7.50 man yrs.
Verification	1.5 yrs.	1.00 man yrs.
Phase 2 -- Extended Implementation --		
Tracking	2.0 yrs.	6.50 man yrs.
Implementation	Depends on Tracking	
Phase 3 -- Interoperability --		
Tracking	5.0 yrs.	5.00 man yrs.
Implementation	Depends on Tracking	
Phase 4 -- Adaptive Implementation --		
Research and tracking	2-3 yrs.	Unknown
Full scale development	3.0 yrs.	Unknown

CLUSTER IV:

OPERATING SYSTEMS AND TOOLS

WIS IMPLEMENTATION STUDY

CLUSTER IV -- Operating Systems and Tools

ATTENDEES

SEPTEMBER 27, 1983

Bail, Dr. William G. *	Intermetrics, Inc.
Buseman, William*	SofTech
Bush, Dr. Eric *	SofTech
Carlson, Mr. William E. *	Intermetrics, Inc.
Crafts, Mr. Ralph E. *	Intellimac, Inc.
Easton, William B.*	WBG, Inc.
Greene, Col Joseph	WIS/JPMO
Harrington, Mr. Richard J. *	Software A&E, Inc.
Sapp, Mr. John W. *	Software A&E, Inc.
Whelan, Mathew J.	NAVINTCOM
Whitaker, Col William	WIS/JPMO
Willis, Mr. Paul A. *	Intellimac, Inc.

*Background information on these people can be found in Volume II of this Record Document

CLUSTER IV:

OPERATING SYSTEMS AND TOOLS

The topic of the Cluster IV workshop session, which was held on Tuesday, September 27, 1983, was Operating Systems and Tools. The session was structured into three separate discussions as follows: Conversion Aids, Operating Systems, and Design Description and Analysis Tools. Each of the discussions will be covered in a separate section of this report.

CONVERSION AIDS

The objective of the Conversion Aids area is to provide a capability to convert existing COBOL and FORTRAN programs into Ada programs. The main benefits of such a capability are to capture the parts of existing WWMCCS software base and to speed the transition from the existing system to WIS.

HIGHLIGHTS OF THE DISCUSSION

The basis for the discussion was the Technical Area Report entitled "Aids for Converting FORTRAN or COBAL to Ada" by Dr. William E. Riddle. As Dr. Riddle was unable to attend the session, the chairman presented a summary of the report. The present state-of-the-art in the area of conversion aids is quite advanced for the translation of programs written from one dialect and operating system to another. For example, conversion aids have existed for years for COBOL conversions. However, there are few examples of successful aids for conversions between languages as different as COBOL and Ada. There are at least two ongoing projects which are doing related work. One is the Interactive Bath Improvement System at the University of Bath in England. The primary focus of the conversion segment of the project is on conversion of FORTRAN to Ada. The Tasmanian Conversion Aid at the University of Tasmania in Australia addresses discovering structure in converting FORTRAN programs into Pascal programs.

Discussions initially centered on the questions ranging from "why bother converting, why not rewrite in Ada" to "why bother converting, why not continue to run the existing programs on the existing hardware." It was decided to leave these management decisions to the JPMO and focus on a technical approach to allow conversion of existing COBOL and FORTRAN programs on the Honeywell computers under the GCOS operating system to Ada in the new WIS environment.

While pure source language translation appears quite feasible, a concern was raised over operating system dependencies in existing WWMCCS programs. It was suggested that Ada packages could be developed to simulate the GCOS file management environment. Three different levels of conversion quality requirements were suggested. At the first, functionality is preserved, but performance and modifiability are not of concern (easy). At the second, good

performance is required (moderate). At the third, the end product is expected to be maintained and modified. Experience with developing and using COBOL conversion aids was discussed. A model for planning and executing conversions including the wide range of activities and products needed beyond the conversion aid was presented.

RECOMMENDED PLAN

A consensus was reached on the approach to take to develop aids to convert COBOL and FORTRAN programs to Ada. The approach is to develop a conversion aid from COBOL to Diana and from FORTRAN to Diana. Then, the Diana intermediate form can be translated either to Ada or directly to target object code using software already being developed for APSE. Transformers of the Diana intermediate form are developed as required for performance or maintainability. This is essentially the approach recommended in Dr. Riddle's report. Existing COBOL and FORTRAN structuring aids could be used to facilitate the front-end conversion process. Tools to aid the conversion process itself are also required including data conversion aids. In addition, the GCOS environment will have to be analyzed, and appropriate Ada packages developed to simulate that required by the existing software.

SCHEDULE AND COST

The overall effort was divided into six tasks with estimated technical effort and elapsed time as follows:

TASK 1 Develop basic FORTRAN to Ada conversion aid (5 man years over 1.5 years)

TASK 2 Develop basic COBOL to Ada conversion aid (5 man years over 1.5 years)

TASK 3 Develop conversion process tools (5 man years over 1 year)

TASK 4 Analyze GCOS environment and develop Ada packages to simulate (8 man years over 1 year)

TASK 5 Develop advanced transformers (6 man years over 1 year)

TASK 6 Test and integrate conversion aids (17 man years over 1 year)

The following schedule was developed:

TASK	START	END	MAN YEARS
1	1/84	6/85	5
2	1/84	6/85	5
3	6/84	6/85	5
4	6/84	6/85	8
5	7/84	7/85	6
6	7/85	7/86	17
	2.5 years		46 man years

OPERATING SYSTEMS

The objective of the Operating Systems area is to provide operating system support for correct execution of Ada object code and general purpose facilities for Ada applications software.

HIGHLIGHTS OF THE DISCUSSION

The chairman began the discussion with an introductory briefing on operating systems area including definition of terms, potential features, and range of options. Next, the two DoD implementations of Ada were presented with emphasis on run time support, the Air Force Ada Integrated Environment (AIE) being implemented by Intermetrics, Inc., and the Army Ada Language System (ALS) being implemented by SofTech, Inc.

After extensive discussion on many operating system topics, the group focused on developing a way to obtain a specification of the operating system required and a way to obtain cost and schedule estimates.

RECOMMENDED PLAN

The consensus reached in the Operating System area was to develop a specification including Ada package specifications and other requirements for the implementation. The recommended approach is to base the specification on the KAPSE Interface Team (KIT) and KAPSE Interface Team, Industry and Academia (KITIA) work on the Common APSE Interface Set (CAIS) specification. Additional work will be needed to resolve open CAIS issues in the WIS context. The set of input/output standards required to be supported must be developed. Database management and multilevel security requirements must be included. An analysis of additional features required in the WIS end-use operating system environment vice Ada programming development/support environment addressed by CAIS must be performed.

SCHEDULE AND COST

The effort to prepare the specification was at 5 man years over 1 year. It was recommended that cost and schedule estimates for the operating system development be developed by first obtaining the Air Force and Army estimates of the KAPSE portions of the AIE and ALS. Estimates for multilevel security can be obtained by analogy from the KSOS and MCF Operating System efforts although caution should be used as most similar efforts have not succeeded, cost over $20M, and required computer hardware modifications. These estimates would have to be augmented by the database efforts from Cluster I and additional efforts required beyond the scope of the KAPSE and CAIS efforts.

DESIGN DESCRIPTION AND ANALYSIS TOOLS

The objective of the Design Description and Analysis Tools area is to provide a capability to develop, describe, and analyze designs of concurrent, Ada-based systems. The main benefits of such a capability are to provide a rigorous methodology for the design process of WIS software development, to assist the preparation of external and internal descriptions of a system's program units, to perform consistency checking, and to aid independent verification and validation.

HIGHLIGHTS OF THE DISCUSSION

The basis for the discussion was the Technical Area Report entitled "A Plan for Acquiring Design Description and Analysis Tools" by Dr. William E. Riddle. As Dr. Riddle was unable to attend the session, the chairman presented a summary of the report in worksheet form. The report essentially described the state-of-the-art and ongoing work in one part of the area and proposed an aggressive research and development program. After discussing the broader area of design methodologies, the general consensus was that WIS needed a design methodology and tools to support it as soon as possible.

RECOMMENDED PLAN

A consensus was reached on the approach to take to develop design description and analysis tools. The approach is to choose an existing design methodology and develop tools to implement it if they are not already available. Byron, an Ada software design and analysis tool developed by Intermetrics, Inc. is a recommended example. Use of an Ada compiler and other parts of an APSE as a backend is recommended to minimize the amount of development.

SCHEDULE AND COST

The overall effort was divided into three tasks with estimated technical effort and elapsed time as follows:

TASK 1 Choose a methodology and define the tools required to implement it (2 man years over 0.5 years)

TASK 2 Implement initial set of tools
(5 man years over 1 year)

TASK 3 Incrementally enhance and add tools
(5 man years over 1 year)

The following schedule was developed:

TASK	START	END	MAN YEARS
1	1/84	6/84	2 man yrs.
2	6/84	6/85	5 man yrs.
3	6/85	6/86	5 man yrs.
TOTAL	2.5 years		12 man yrs.

WIS IMPLEMENTATION STUDY

IDA ATTENDEES

SEPTEMBER 22, 23, 27, 1983

Campbell, Mr. J Frank *

Knapper, Mr. Robert J.

Kramer, Dr. John F. *

McDonald, Ms. Catherine W.

Probert, Dr. Thomas H. *

Slusarczuk, Dr. Marko M.G. *

*Background information on these people can be found in Volume II of this Record Document.


DATE
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