RL-TR-91-384, Vol II (of three)
Final Technical Report
December 1991

(2)

ADVANCED COMMAND AND CONTROL ENVIRONMENT (ACCE) INTEGRATION Concept of Operations

Knowledge Systems Concepts, Inc.

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY (Leave Blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	December 1991	Dec 90 - Jun 91

4. TITLE AND SUBTITLE
ADVANCED COMMAND AND CONTROL ENVIRONMENT (ACCE) INTEGRATION, Concept of Operations

5. FUNDING NUMBERS
C - F30602-87-D-0085, Task 20
PE - 62702F
PR - 5581
TA - Q4
WU - A1

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8. PERFORMING ORGANIZATION REPORT NUMBER
N/A

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Rome Laboratory (C3AA)
Griffiss AFB NY 13441-5700

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
RL-TR-91-384, Vol II (of three)

11. SUPPLEMENTARY NOTES
Rome Laboratory Project Engineer: David L. Marks/C3AA/(315) 330-7764

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)
This report summarizes the work conducted under the Advanced Command and Control Environment (ACCE) Integration task. The ACCE is a facility which aids in assessing the operational utility, feasibility, and acceptability of advanced display presentation systems technology to Air Force command and control problems. This task's objective was to provide basic planning and integration support for the evolutionary development and incremental expansion of the ACCE. Advanced display presentation technologies emphasized within the ACCE included three dimensional (3D) stereoscopic display technology utilizing a time-multiplexed liquid crystal stereoscopic shutter (LCSS) system, and volumetric display display technology which presents the visual equivalent of a physical model by projecting a scene onto a vibrating mirror. Under the task, Knowledge Systems Concepts (KSC), Inc. provided overall ACCE program guidance, system design support, and integration support. KSC enhanced the baseline ACCE hardware and software environment, and developed the ACCE Display Evaluation Prototype(ADEP). The ADEP simulates an Air Defense Initiative (ADI) scenario on the advanced 3D display devices resident in the environment.

14. SUBJECT TERMS
Advanced Command and Control Environment (ACCE), ACCE Display Evaluation Prototype (ADEP), Air Defense Initiative (ADI), 3D Stereoscopic Display, 3D Volumetric Display

15. NUMBER OF PAGES
52

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UL

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2 89)
Prescribed by ANSI Std Z39-18
298-102

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Chapter 1

Introduction

1.1 Purpose

This report documents the Concept of Operations (CONOPS) for Rome Laboratory's Advanced Command and Control Environment (ACCE). Knowledge Systems Concepts, Inc. has prepared the report under ELIN V003 of Contract F30602-87-D-0085/0020, entitled "Advanced Command and Control Environment Integration", for the Applied Command and Control Systems Division (COA) of Rome Laboratory (formerly Rome Air Development Center).

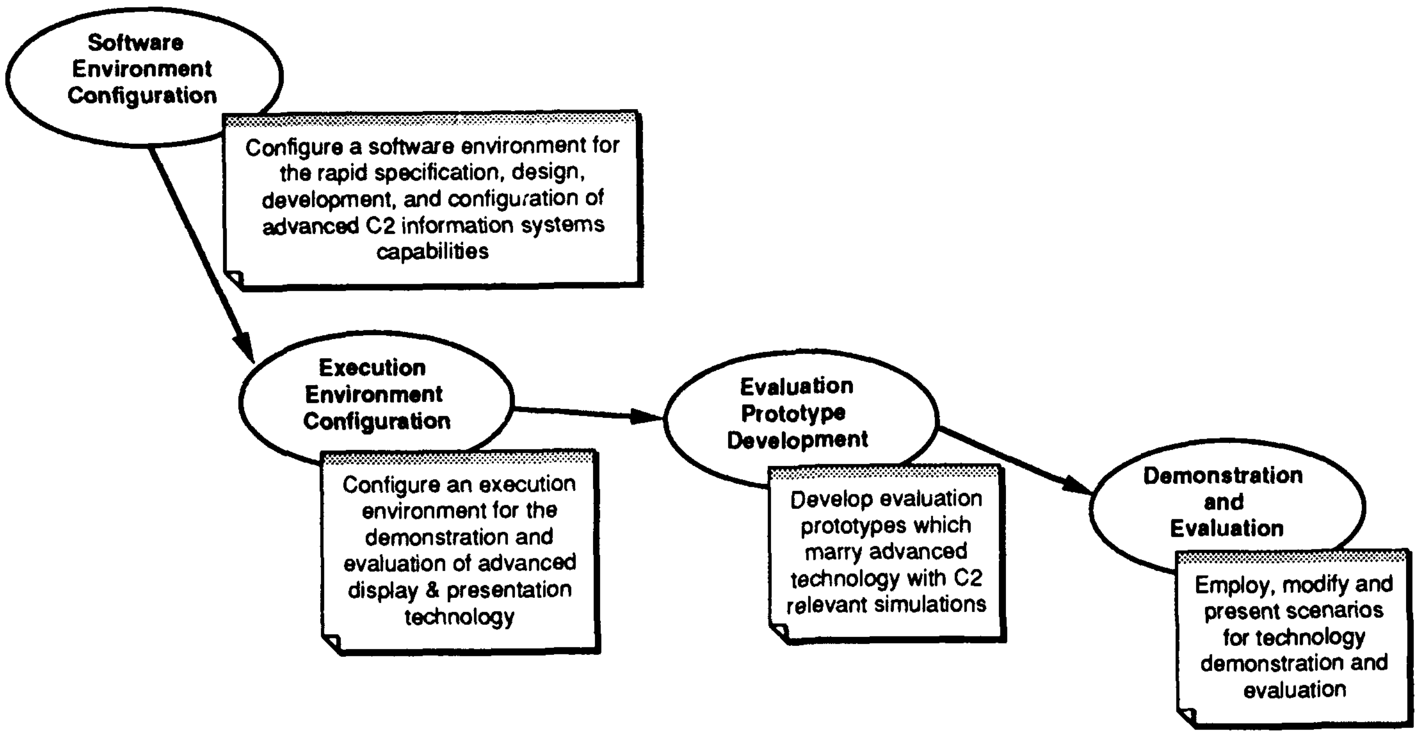
The ACCE Integration contract has two major objectives. The first objective, as illustrated in Figure 1.1-1, is to establish a near term baseline hardware/software testbed environment. In this respect, KSC will use available computer systems to evaluate advanced displays, and related human-machine interface (HMI) technology developments to satisfy selected command and control requirements.

The second objective, illustrated in Figure 1.1-2, is to provide a planning framework for the evolutionary development and incremental expansion of the ACCE baseline. KSC has prepared this Concept of Operations report as part of this planning framework objective. Its purpose is to specify the ACCE, and to provide guidelines for the conduct of research in the ACCE facility. The document does this by outlining the composition of the ACCE, how it will function, who will use it, and lists the primary organizations with whom it must interface.

1.2 Technical Information Report Organization

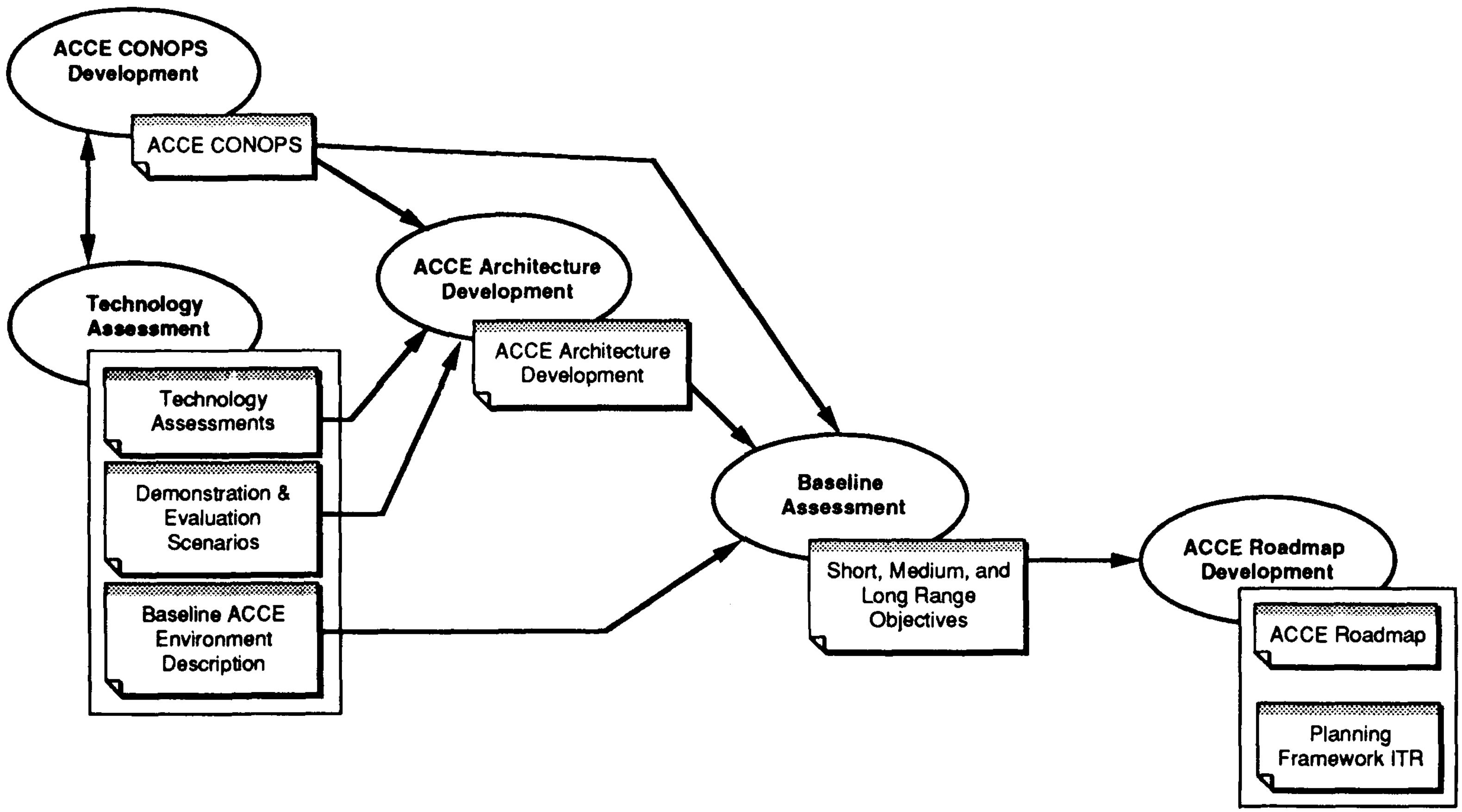
This ACCE Concept of Operations (CONOPS) Technical Information Report is organized into four chapters and three appendices. **Chapter 1** states the objectives of the ACCE, provides background information, and outlines the goals of the ACCE contract. **Chapter 2** is the heart of the report. It outlines the concept of how the ACCE will bring together the Air Force C2 requirements and the pertinent advanced technologies. It also provides guidelines that show how potential technology solutions to the requirements might be tested, evaluated and eventually integrated into C2 systems. The chapter includes a description of the ACCE role within the Rome Laboratory organization, and emphasizes the technology transfer opportunities available through the collocated Command and Control Technology Center. **Chapter 3** describes the hardware and software resources that will be available to support the technology assessments. It also provides the framework for an organization to manage these resources. **Chapter 4** is a summary of ACCE objectives.

Objective:
"Integrate components into a basic infrastructure of computers, peripherals, presentation equipment, communications devices, system software, and support software."



ACCE System Integration Support Task Flow Diagram
Figure 1.1-1

Objective:
"Develop a planning framework for the evolutionary development and incremental expansion of the ACCE."



ACCE Planning Framework Task Flow Diagram
Figure 1.1-2

Appendix A examines three Rome Laboratory research and development programs and provides examples of how ACCE activities could be used to support and benefit these specific programs. **Appendix B** expands the description of ACCE resources provided in Chapter 3, and outlines how each resource type might help in the evaluation of advanced technology for the C2 domain. **Appendix C** is an alphabetical list of acronyms used in this report.

1.3 Background

Command and control (C2) is the process and means by which a commander exercises authority and direction over assigned or operationally controlled forces. The commander must quickly assimilate and make sense out of huge volumes of information and then make accurate decisions critical to the battle. Often these decisions are made during times of extreme duress. Automated systems that help commanders to quickly sort and evaluate the situation can facilitate the command and control process. Although bits and pieces of technology have found their way into C2, many C2 means are still largely manual. The problem does not appear to be a lack of technology, but lack of a mechanism for transitioning that technology into C2. This was the conclusion of the 1989 Command, Control and Communications (C3) Technology Assessment Conference sponsored by the Defense Communications Agency (DCA), the Joint Director of Laboratories Technical Panel for C3 and the National Security Industrial Association. Among their findings was the need for further emphasis on the development of technologies to enhance human-machine interaction for C2. They also cited the need to develop laboratory facilities to support the technology insertion process.

In response to the 1989 conference finding, Rome Laboratory established the ACCE to assess the operational utility, feasibility and acceptability of advanced display presentations and HMI technologies for C2.

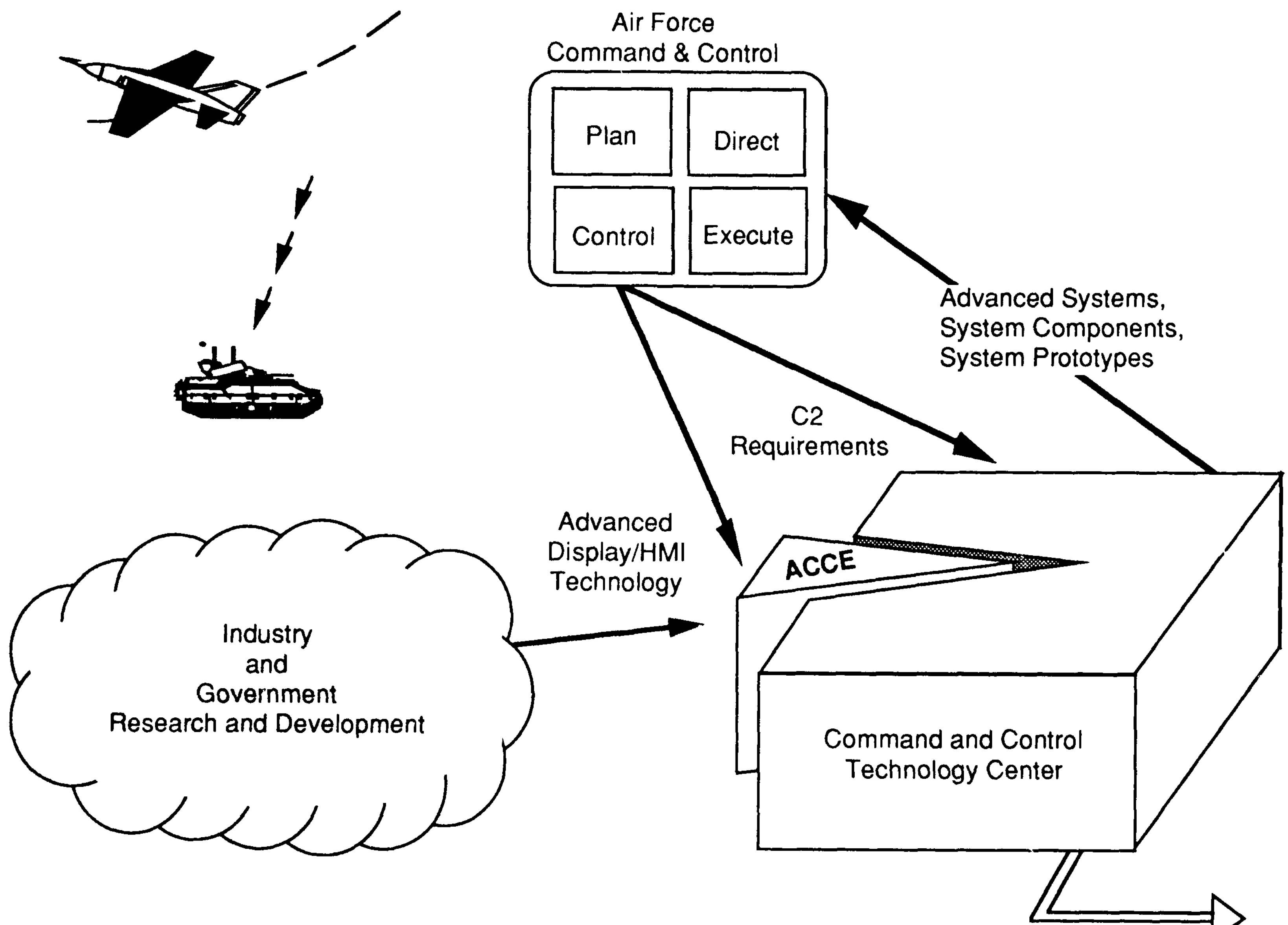
1.4 ACCE Program Objectives

The primary objective of the ACCE is to implement a testbed laboratory environment to apply, evaluate, showcase and exploit advanced display and HMI technologies that have the potential to impact next generation C2 systems. The ACCE will provide a rapidly reconfigurable workbench-like environment where candidate technologies may be evaluated by engineers and users based on selected C2 requirements. Although certain operating conditions within the laboratory may be simulated, they will be realistic enough to conduct a rigorous behavioral analysis of the technology. Significantly, the ACCE allows technology evaluation prior to expensive integration of the technology into advanced development models. Strengths and weaknesses can be identified and engineering modifications recommended. Once the ACCE engineers establish the viability of a technology, C2 system developers may tailor the technology to meet specific C2 applications. This approach not only results in a better product, but it is cost effective since the utility of the technology will be determined before a substantial system integration investment is made.

Figure 1.4-1 illustrates a high level view of the ACCE concept. It shows how the ACCE fits into the total research and development picture as an integral part of the Command and Control Technology Center (C2TC). The C2TC is a Rome Laboratory computer-based facility where users evaluate Command and Control system level capabilities using realistic encounters with opposing forces. The C2TC examines a number of different technologies such as expert systems, correlation and fusion, and simulation. The C2TC staff demonstrates these advanced technologies to potential users, and those that satisfy requirements are integrated into C2 systems. From the C2TC, advanced systems, system components, and system prototypes are transitioned into the Air Force C2 environment.

The ACCE differs from the C2TC in several respects. *First*, the ACCE has a more specific charter. It exclusively supports the analysis and evaluation of advanced presentation and HMI technologies. *Second*, with a narrower scope, it will only focus on bringing technology to bear on C2 HMI and display problems. The C2TC, on the other hand, examines a wider range of technologies to solve their wider range of problems. Thus, the ACCE will provide a laboratory facility complete with equipment, resource libraries, a support infrastructure, operational procedures and a development strategy specifically for applying state-of-the-art interface technology to C2.

The ACCE and C2TC will work in concert to address the technological needs of the C2 community. For example, a program in the C2TC might generate a requirement for a display technique that is beyond the scope of that particular program. ACCE engineers could then apply their resources to the problem to develop a candidate solution. Conversely, HMI researchers in the ACCE might identify potential solutions for problems that need the total system capability of the C2TC to confirm their operational worth. Additionally, C2TC or other Rome Laboratory programs can draw upon the ACCE repository of previously evaluated advanced interface technology. Therefore, instead of multiple projects redundantly evaluating the same HMI technique, they may each tap the ACCE for proven technology that meets their requirements.



ACCE Concept
Figure 1.4-1

Chapter 2

The ACCE Concept

2.1 Introduction

The problems to be solved in the ACCE are based on requirements established by the C2 community There are several interpretations of what comprises C2, but only one definition standardized by the U.S. Department of Defense and published in Joint Pub 1-02, Department of Defense Dictionary of Military and Associated Terms, 1 December 1989. It states that:

> Command and control is *"the exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures employed by a commander in planning, directing and controlling forces and operations in the accomplishment of the mission."*

This chapter outlines the concept of how the ACCE staff will take the specific C2 requirements and then identify, evaluate and recommend new HMI and display technology to satisfy these requirements. It includes a rundown of the potential users of the ACCE, the interfaces needed to optimize the problem solution, and the ACCE task flow concept.

2.2 ACCE Users

Rome Laboratory plans to employ the ACCE to support diverse categories of users involved in presentation systems technology activities. These range from engineers conducting in-house research with limited aims, to users that will test and evaluate technological enhancements for fielded operational systems. Each category of ACCE user will have specific goals and expectations and may apply the ACCE in different ways to support their technical objectives. This section outlines the ACCE's anticipated user community and some of their perspectives.

2.2.1 Rome Laboratory Research and Development (R&D) Engineers and Contractors

Two primary ACCE users are the government R&D engineering staff, and private R&D contractors working outside the Laboratory on ACCE-related efforts. The ACCE goals of these staffs are as follows:

- To provide improvements in information presentation and HMI technology to the C2 community.

- To refine promising information presentation and HMI technology and apply it to a specific C2 user requirement.
- To demonstrate to the end user C2 community advances in information presentation and HMI technology within the C2 context.
- To identify and delineate ACCE-related technology requirements for pertinent development efforts.
- To determine the technical feasibility of incorporating ACCE-related technology into specific programs, given user requirements, budget, and schedule constraints.
- To introduce systems development contractors to the advanced information presentation and HMI technologies that are available at Rome Laboratory so they can be incorporated in C2 systems development efforts.
- To provide recommendations to Rome Laboratory senior managers concerning those technologies that should receive the highest acquisition priority.

2.2.2 Rome Laboratory R&D Management

The goals of Rome Laboratory management personnel will be more program-oriented and on a broader scale than those of the R&D engineering staffs. Rome Laboratory managers will be more interested in reviewing ACCE demonstrations to support their decision-making tasks regarding issues such as:

- Identifying those promising ACCE-related technologies that should receive funding priority.
- Identifying opportunities to transfer useful ACCE-related technologies to other R&D efforts.
- Establishing R&D efforts to support the transition of successful 6.1 and 6.2 ACCE-related technologies to capabilities that can be incorporated in C2 systems.

2.2.3 Air Force C2 User Community

The Air Force C2 community is responsible for the most important part of the ACCE program: the definition of requirements. These requirements bring operational relevance to the ACCE program and are the primary driver for any ACCE activities. The Air Force provides requirements to Rome Laboratory as official Statements of Need (SON). These SONs justify the timely allocation of resources to achieve a capability to accomplish approved military objectives, missions or tasks.

Air Force C2 users normally take a pragmatic view of technology capabilities. Their primary goal will be to determine whether the technology they see in the ACCE will help them do their jobs more efficiently and increase productivity. Given a favorable outcome from the ACCE demonstrations, they will be concerned with any impact the insertion of ACCE-related technology will have on their systems and organization. The C2 community will have questions concerning the following areas:

- The compatibility of the technology with their current systems.
- The staff training implications involved in exploiting the technology benefits.
- The C2 staff personnel skill types required to use the technology.
- System reliability, maintenance and logistic considerations.
- Costs and schedules.

C2 users will also provide feedback from ACCE demonstrations in areas such as product improvement, and design considerations to ensure that ACCE technology results in a useful system capability.

2.3 ACCE Interfaces

The ACCE must establish effective interfaces with the potential users cited above to ensure that the substantive inputs from the different viewpoints are fully exploited. The ACCE also has a requirement to interface with outside agencies such as university consortia to obtain details on new technology developments. Four primary types of information must be obtained and shared across the interfaces:

1. **Requirements**: The Air Force C2 community must provide their requirements to the ACCE, C2TC and other Rome Laboratory components. These requirements include: user interface items - directed to the ACCE; system items - directed to the C2 Directorate engineering staff and project managers; and program items - directed to Rome Laboratory upper management.

2. **Knowledge**: Rome Laboratory directorates and research facilities must share knowledge concerning what has been learned in their experiments about implementing HMI and display technologies. Knowledge can be transformed into expertise, but its value is limited unless it can be accessed by others.

3. **Technology**: Information concerning the capabilities of new technology needs to be recorded, assessed and distributed to others for review.

4. **Resources**: Whether the resource is hardware, software, or data, these types of assets need to be pooled and shared among the ACCE and other Rome Laboratory components. This could translate into secure communication links being established among the various laboratory components for selected experiments.

This ACCE interface concept is illustrated in Figure 2.3-1. The following paragraphs expand upon this concept and explain the roles and interaction among the various components.

2.3.1 The Air Force C2 User Community Interface

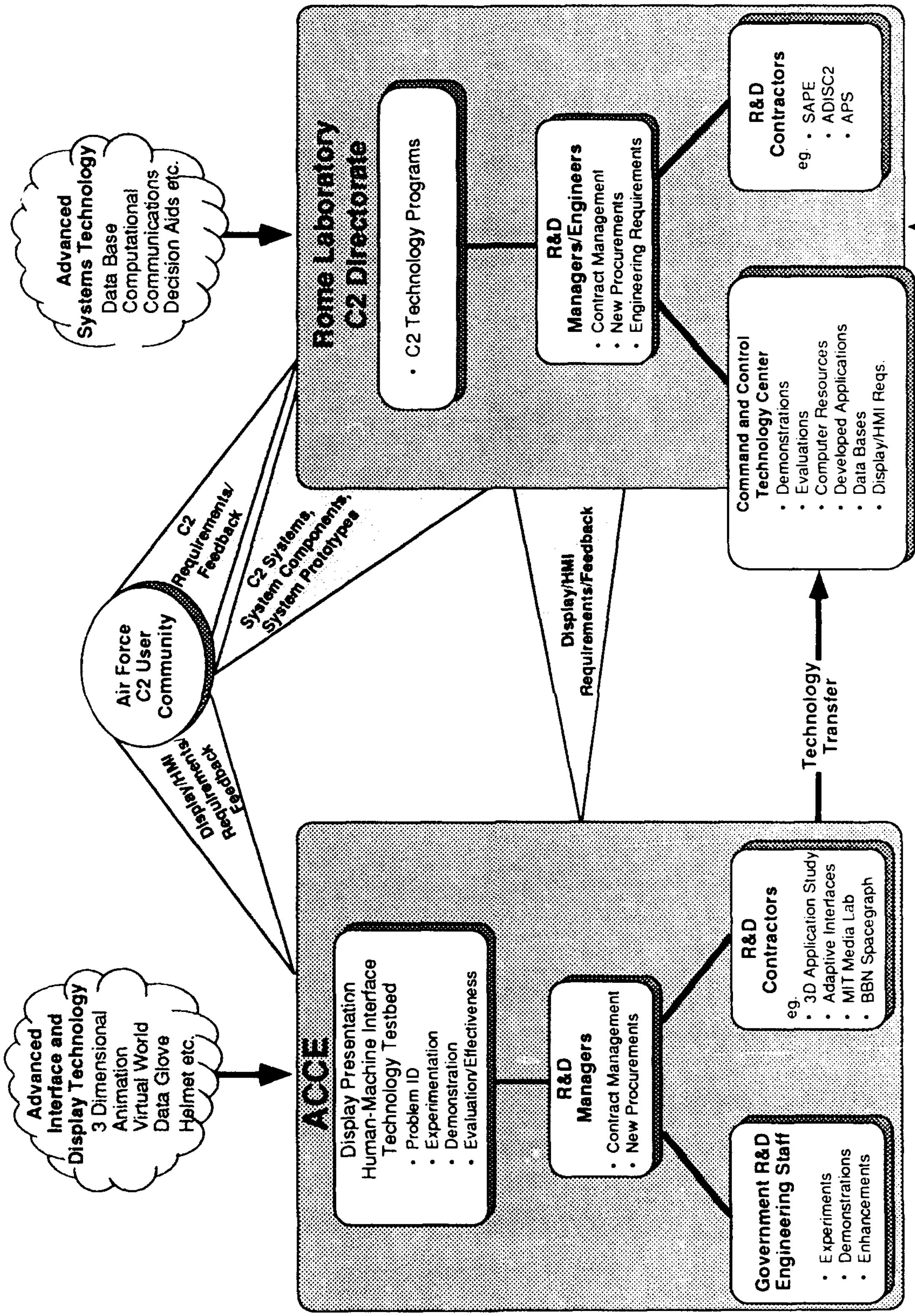
This is a key component of the ACCE interface concept because it is from Air Force C2 requirements that the ACCE obtains its focus. The ACCE interface will consider the general and unique requirements of the various Air Force commands, plus procedural guidelines for such interfaces that the Air Force Systems Command has established.

2.3.2 The Advanced HMI and Display Technology Community Interface

The ACCE must develop a systematic way to track display/presentation and HMI technological advancements made in the commercial, government and academic worlds. This means that the ACCE needs to maintain inputs from this community in an ACCE Resource Library. This library would contain details on new technology and how it has been applied to activities similar to C2. A new text retrieval system might be one method of storing and retrieving such data. For example, a Generic Input Processor is being built by Rome Laboratory that can be reconfigured for a multitude of information sources, types, formats and fields of interest by simple changes to the parameters presented in an interactive user interface. Such a system could provide the capability to input details on new HMI and display technologies, and translate them into a product useful to the ACCE staff.

2.3.3 Rome Laboratory Command and Control Directorate (CO) Interface

The association between activities conducted within the ACCE and those conducted by the Rome Laboratory Command and Control Directorate is a natural one; the ACCE is organizationally assigned to CO. As depicted in Figure 2.3-1, the ACCE and CO are envisioned to concurrently conduct R&D. Many CO efforts are subtasks of a project plan formulated to fulfill long-term objectives. Other CO efforts focus on developing complete systems that ultimately will support C2 end users. CO's technological areas of interest include data bases, system development tools, computer hardware and software, and data processing methodologies. These new technologies are refined and integrated into advanced development models and prototypes. C2 systems include applications such as battle management decision aids and battlefield activity simulators. Besides developing fully functional systems, some efforts concentrate on refining a



ACCE Interface Concept
Figure 2.3-1

particular high payoff technology to a point where it may be integrated into a variety of C2 applications. Natural language processing, distributed data base management or data fusion algorithms are examples of these types of technologies. The establishment of the ACCE, with its HMI and display technology charter, will allow CO program managers to concentrate on the other development challenges.

A current major objective of CO is to explore, develop and apply technology that can provide effective, survivable command and control. In pursuit of this objective, CO has developed a technical approach to achieve three major interrelated C2 goals. Briefly stated, these goals are as follows:

1. **Goal**: Reduce C2 planning cycle times.
   Approach: Incorporate artificial intelligence based decision aids into battle management information management systems.

2. **Goal**: Increase C2 survivability.
   Approach: Disperse/distribute physical assets and computer processing.

3. **Goal**: Improve information communication and dissemination.
   Approach: Employ advanced information processing and display technology.

In direct response to these goals, three large Rome Laboratory CO programs have been established under which many more specific subefforts fall. These are listed in Figure 2.3-2.

Major Programs	Subefforts
Air Defense Initiative	Air Defense Initiative Simulation for Command and Control (ADISC2) Air/Sea Fusion Display Battle Staff Decision Support
Strategic Command and Control	Survivable Adaptable Planning Experiment (SAPE) Phases I - IV
Tactical Battle Management	Advanced Planning System (APS). Tactical Air Control System (TACS) Replanning C2TC Distributed Data Base Feasibility Demonstration Operations - Intelligence Integration Defensive Planning

Current Rome Laboratory Programs and Subefforts
Figure 2.3-2

The programs listed above are prime examples of candidate efforts that might reap benefits from work conducted in the ACCE. Appendix A examines one subeffort from each Rome Laboratory Major Program area listed in Figure 2.3-2, and provides illustrative examples of how the ACCE could support and benefit them.

2.3.4 Command and Control Technology Center (C2TC) Interface

The C2TC is a laboratory testbed facility where government engineers supervise the conduct of comprehensive experiments using realistic C2 encounters. Many systems developed in CO and other Rome Laboratory directorates are rehosted in the C2TC just for this purpose. Demonstrations conducted before C2 users and R&D engineers generate valuable feedback that can be used to refine the application and define requirements for new efforts.

The ACCE's primary interface will be via the C2TC. The primary reason is that the ACCE is physically located within the C2TC. Second, a central facility, such as the C2TC, that has the charter to help C2 technology transfer, is the logical interface choice. While the ACCE will develop an experiment to show the application of a specific display or HMI technology such as an eye tracking device, the C2TC will have the capability to take that particular technology and integrate it into a specific C2 application. In this setting, further experimentation and analysis can be conducted to assess its usefulness. For example, questions may be answered concerning the impact of the device on the performance of other system functions. C2TC experiments may suggest engineering modifications to the technology that in turn would be carried out in the adjacent ACCE.

The following examples summarize the types of ACCE support to be provided by the C2TC.

- **C2 User Interface and Display Requirements**: The C2TC can identify HMI and display requirements to the ACCE. For example, system developers sometimes cannot deliver the most optimum HMI under a specific contract due to time, financial or technological constraints. In other cases, experimentation and demonstrations in the C2TC, for C2 users, might identify desired HMI improvements. Both of these situations identify requirements that may be candidates for ACCE action.
- **C2 Applications**: The ACCE will apply and evaluate the applicability of raw technology to display HMI needs identified in the C2TC. If the results of experimentation within the ACCE show that the particular technology may be a viable solution, further experimentation and analysis must be performed. The C2 applications residing in the C2TC provide the ideal hosts for this refinement. For example, ACCE experimentation in a stand-alone mode may reveal that animated 3D graphics convey information more appropriately than 2D. But when the function is integrated into a C2TC system, the added

burden of 3D processing might degrade the total performance of other functions to an intolerable level.

- **Data**: Various types of data are required to drive and test display and HMI techniques. Rather than have the ACCE generate this data for each experiment, the ACCE could obtain the required data from previously completed C2TC or other CO efforts. Prime examples include intelligence, operations, scenario and cartographic data. In addition, selected communications links to other laboratories and systems could provide real-time data inputs to the ACCE.

- **Algorithms**: In cases where a display or HMI experiment requires some form of data preprocessing, algorithms developed under previous efforts may be used. Not only would this approach save money and time, but using previously tested algorithms would minimize the risk of errors and provide a known baseline. Projection transformations, radar profile algorithms, and missile trajectory algorithms are some examples.

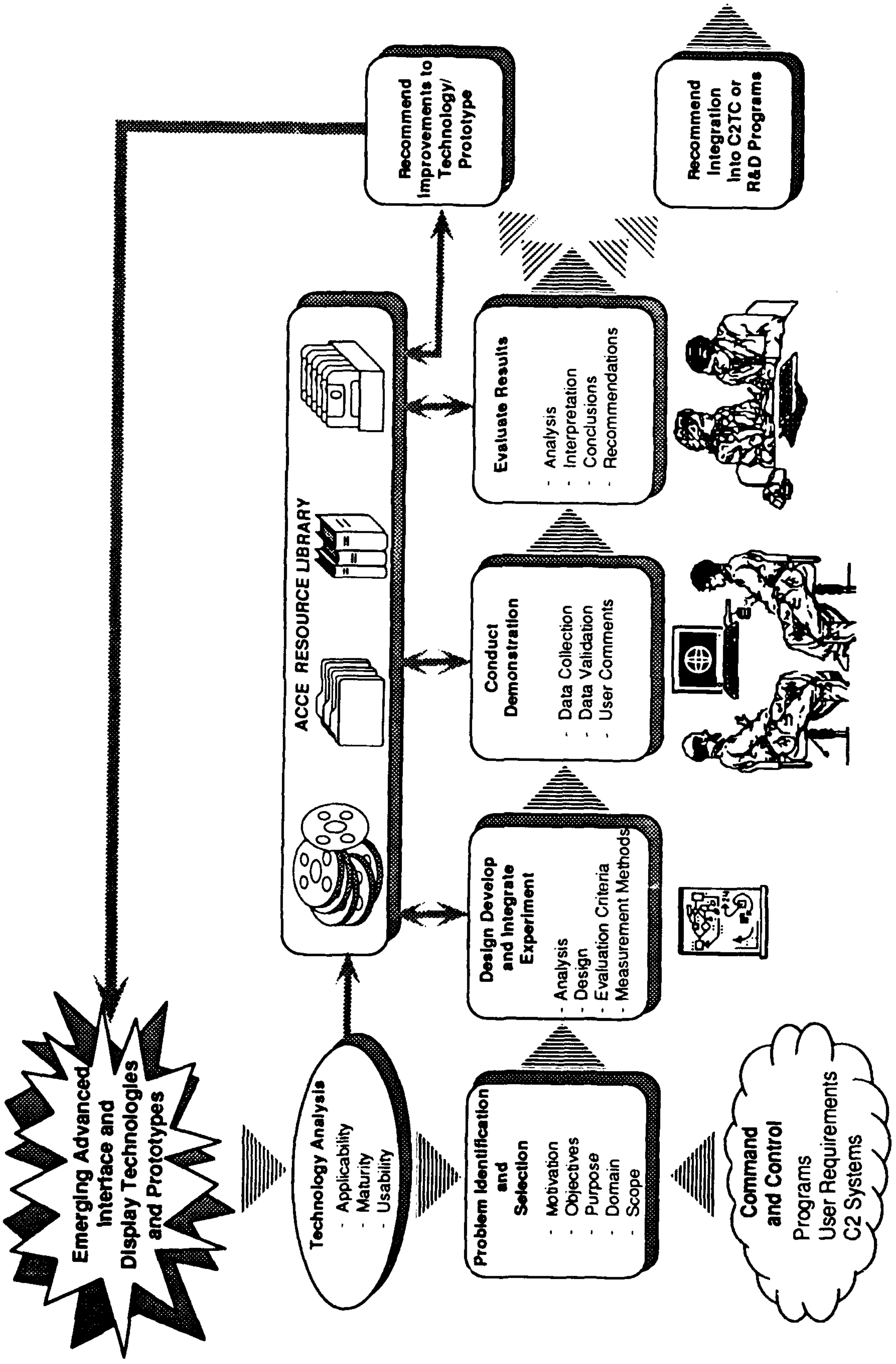
- **Computational Resources**: ACCE experiments may identify the need for computer hardware that is currently not part of the ACCE configuration. However, the C2TC possesses a vast collection of computer resources that could be available to support ACCE experiments. In instances such as these, ACCE and C2TC agreements can provide for the collective use of laboratory assets.

- **Demonstration Environment**: Besides the computation resources described above, the physical assets of the C2TC laboratory facility could be shared as well. The C2TC is equipped with a command center display room designed specifically to support briefings. This facility provides an ideal environment to demonstrate the viability of various types of large screen display technology.

Although the above list is not exhaustive, it shows that the C2TC, with its repository of C2 applications and system resources, can provide valuable input and support to the ACCE.

2.4 The ACCE Task Flow Concept

The ACCE will support the previously described users in their assessment of the utility, feasibility, and acceptability of advanced information presentation technology applied to Air Force C2 problems. The process is depicted in the ACCE Task Flow Concept graphic, Figure 2.4-1. The activities conducted under each task are described in the following paragraphs. Where possible, examples have been used to further illustrate task ideas. The resource library is shown in the figure as a repository of software, data and R&D evaluation results. All tasks interface to the ACCE resource library to preclude redundant development and to enforce the idea of reusability.



ACCE Task Flow Concept
Figure 2.4-1

2.4.1 ACCE Problem Identification and Selection

ACCE problem identification and selection is the first task in the process and involves identifying a C2 problem that ACCE developers believe can be solved through experiments involving the application of advanced HMI or display technology. The C2 requirements are obtained directly from Air Force Commands' Statements of Need or indirectly from C2 contracts' Statements of Work. The requirements provide official motivation for the ACCE experiment. At the same time, the ACCE staff will have been conducting an on-going technology analysis review to ensure that they are up-to-date on the latest advancements. The ACCE staff, by having knowledge of both C2 user needs and technology, can visualize potential matches between the two.

2.4.2 Design, Development and Integration of ACCE Experiments

Once the C2 problem has been identified and potentially suitable technology to solve the problem has been selected, an experiment must be devised to gauge the effectiveness of the technology. Experiment development is a planning process that determines how the experiment should be structured and conducted, and how the success or failure of the technology should be measured. It is an extremely important process because the way the experiment is designed can sometimes influence its outcome. A technology may be the perfect solution, but due to inappropriate experiment definition, implementation and evaluation, it may be rejected.

Many issues must be considered when designing an experiment of this nature. First, ACCE experiments must be devised with realism in mind. Since the ultimate goal of the ACCE demonstration is to provide the C2 user with an improved interface, the ACCE staff must ensure that the experiment is as realistic as possible. This may even include simulating such factors as stress, heat and time constraints encountered by the user during actual battle situations. ACCE developers must be familiar with the user and his specific requirements. Therefore, the user must be involved early in the experiment definition phase, as opposed to being brought in solely to evaluate the product.

Human-computer interaction research presents specialized problems that make it different from traditional computer engineering research. Without getting too deeply into this complex issue, probably the greatest problem facing the ACCE staff is the variability of behavior of the human. For the most part, ACCE experiments will involve evaluating alternate solutions to specific human-computer interaction problems. This involves comparing one technique to another. Simple examples may be the use of monochrome versus color, or keyboard versus touchscreen. The problem is such that often quantitative evaluation criteria cannot be established. Therefore, evaluation is primarily of subjective nature. Unfortunately, one person's preference may be another's dislike. Although only touched upon above, it is apparent that experiment developers must be knowledgeable of the special problems associated with doing research in human-computer interaction.

Another experiment definition issue involves software design and development. Although complete systems will not be developed, there is still the need to follow sound structured design methods to simplify future integration of the component. Therefore, each experiment will require some degree of analysis, design, and development. Since a goal of the ACCE is to minimize software development by making use of existing resources, the analysis phase should include audits of existing systems. Innovation in design and conformance to standards are also important. In addition, the data needed to generate a display can often be isolated from algorithms that produce it. This means that ACCE experiments could bring together system components developed previously under other R&D efforts and simply modify the way the data is output, or how the system is controlled by the user. Sometimes the data generation algorithms may be replaced by a file containing the captured results of the algorithms. Again, the ACCE library idea comes into play in that its contents may support a variety of experiments. Besides software, the library can supply information such as cartographic data, sensor data and intelligence data to drive experiments. Conversely, software developed or data generated during an experiment will be recorded in the library.

An important part of the experiment development and integration task that must not be overlooked is documentation. In fact, appropriate technical documents should be prepared throughout the course of experiment definition. Examples include functional descriptions, requirements specifications, technical reports, design documents and demonstration/test descriptions. Test plans may include evaluation forms, surveys or questionnaires to be completed by the users during the demonstration.

2.4.3 Conducting the ACCE Demonstration

Following design and development, the demonstration phase involves executing the experiment. The major intent of a demonstration is to showcase the innovative application of an advanced display/presentation or HMI technology to a particular C2 problem. It is anticipated that the nature of each ACCE demonstration will be governed by the motives of the audience. Following are descriptions of demonstrations for three groups of individuals. Usually the developer will be responsible for either giving or monitoring the demonstration.

1. **C2 Users**: These individuals will be called upon for their operational expertise throughout the experiment development and demonstration process. During development, interim informal demonstrations may be conducted for C2 users to solicit their opinion concerning the realism of the experiment or the merit of the technology. This feedback can be used to refine the technology, the test measurement criteria or technology implementation plans. Final demonstrations are formal and conducted

according to a previously formulated test plan. The objective of these demonstrations will be to measure whether the technology experiment meets the operational goals. Therefore, they normally will feature the C2 user as the operator. The demonstration may be repeated for a representative sample of C2 users and the evaluation results statistically analyzed.

2. **Rome Laboratory R&D Engineering Staffs**: R&D staff interest in demonstrations are primarily technically oriented. Experiment developers will need to conduct demonstrations to promote the technological exchange of information and ideas with other R&D developers. R&D staffs will be interested in investigating how a technology can be adapted to their particular problem. They will be most interested in the mechanics of the implementation. Questions with respect to cost, performance, processing requirements, development language and complexity may be raised. In addition, R&D staffs may offer technical advice to the ACCE experiment implementor regarding potential alternatives and solutions to observed problems.

3. **Rome Laboratory R&D Management**: Being more program oriented, these individuals will want to see a demonstration that highlights the benefits of the technology. They may review C2 user evaluations, but they will seldom be involved in testing themselves. R&D managers will be interested in functionality. Having broad knowledge of C2 program goals, plans, and funding, they will decide where else the technology fits within the complete development roadmap. In addition, their connections with other laboratories will ensure promulgation of the technology throughout the user community.

2.4.4 Evaluating the Results of an ACCE Experiment

The purpose of evaluation is to decide whether the specified C2 requirements or characteristics are satisfied by the technology under test. The primary criterion should be how well the C2 system hardware or software supports the commander and battle staff decision process.

Evaluations in the ACCE will determine the utility, feasibility, and acceptability of advanced display and user interface technology for Air Force command and control information systems. These evaluations of the empirical data provide guidance to Rome Laboratory engineers, users, and management in the areas of user interface effectiveness, functionality and design trade-offs. It is important that these evaluations are completed in an environment that is operationally representative since systems that perform well in the laboratory often do not "scale-up" to operational requirements.

Effectiveness evaluations address how well an advanced user interface capability results in improved user performance, better decisions, or more accurate and complete C2 products such as air tasking orders and target lists. These evaluations are intended to decide how well the advanced user interface improves understanding of the data, provides convenient interaction with the application software, and enhances natural control over the system.

Specific components need to be identified for assessment before evaluations can be performed in the ACCE. The exact items will depend on the specific C2 user requirements and the technology under review. To illustrate the evaluation process, Figure 2.4-2 below presents selected items that the ACCE staff could evaluate to determine the usefulness of the new display and interface technology to C2. Included in the table are examples of some values that could be added by advanced user interfaces to meet C2 requirements.

Evaluation Items	Value Added
Ease of Use	Browsing Formatting Interfacing I (Mediation) Interfacing II (Orientation) Ordering Physical Accessibility
Tailored/Focused Data	Access 1 (Item identification) Access 11 (Subject description) Access 111 (Subject summary) Linkage Precision Selectivity
Quality	Accuracy Comprehensiveness Currency Reliability Validity
Adaptability	Problem Solving Output Flexibility Simplicity Stimulatory
Time-Saving	Increased Response Speed
Cost-Saving	Lower Prices

Evaluation and Improvement Criteria
Figure 2.4-2

C2 personnel must be involved in the analysis of the ACCE test results. The ACCE staff will be able to draw conclusions about the test and make recommendations concerning how to implement or adjust the technologies; but ultimately, it will be the C2 staff that will decide how well the new C2 system hardware or software supports the commander and battle staff decision process. Once the test results have been analyzed, the ACCE staff will recommend either improvements to the technology prototype or integration of the technology into C2TC activities.

Chapter 3

ACCE Resources and Management

3.1 Introduction

This chapter describes the hardware and software resources available to the ACCE users. It also describes the organization that will manage these resources.

3.2 ACCE Resources

The idea for the ACCE was conceived several years ago so there are several resources already available. The following sections review the current resources and outline potential resources that might be applied to the C2 requirements area.

3.2.1 Current ACCE Resources

Of the various systems and system components initially in the ACCE facility, two primary systems are of interest to this effort. They are the BBN SpaceGraph System and the Silicon Graphics/Stereographic System. Figure 3.2-1 lists and classifies the major resources available with the BBN SpaceGraph System, while Figure 3.2-2 does the same for the Silicon Graphics/Stereographic System. Although somewhat restricted in focus, these two workstations provide the opportunity to evaluate the feasibility of using various 3D presentations to enhance specific situation presentations for C2 staffs.

3.2.2 Potential ACCE Resources

It is anticipated that additional resources will be applied to the ACCE environment as its use evolves. Resources that could be used include both hardware (computers, data base machines, monitors, etc.) and software (operating systems, data bases, graphics routines, communications protocols, etc.). These resources have been organized into five basic groups to facilitate discussion.

1. **Display/HMI Resources**: Includes display hardware (such as CRT displays, projection displays, specialized 3D display devices), HMI hardware (such as keyboards, mice, specialized electronic joysticks, gloves, helmets, and voice input devices), and a variety of software needed to access and use the advanced hardware devices.

Display/HMI Resources	3 Button Mouse
	6 Axis Spaceball
	Dials and Buttons Box
	GT Graphics Option
	Pointing Device Drivers
	Silicon Graphics 4D Gifts Software and Source Code
	Silicon Graphics Keyboard
	Stereo Graphics 3D Presentation Software and Source Code
	Stereographic Z Screen
	Summangraphics Digitizer with 4 Button Mouse
Computational Resources	Silicon Graphics IRIS 4D/70 Workstation
	MITRE Software and Source Code for 3D Display for Battle Management Program
Communications Resources	Ethernet Interface, 10 Serial Interfaces
	Hayes 2400 Baud Modem
	Unix Ethernet Software
Control Resources	Unix Operating System
	Unix C Compiler

Silicon Graphics/Stereo Graphics System Resources
Figure 3.2-1

Display/HMI Resources	EGA Display Controller and Color Monitor
	SpaceGraph Display
	Z-248 Keyboard
	Microsoft Mouse
Computational Resources	EMACS and DOS Line Editors
	SpaceGraph SG Program
	Turbo C Compiler, Microsoft C Compiler Version 6.0 (Programmers Workbench)
	Zenith Z-248
Communications Resources	3COM Ethernet Interface
	Ethernet Software
Control Resources	Zenith DOS Version 3.3

BBN SpaceGraph System Resources
Figure 3.2-2

2. **Computational Resources**: Includes computational hardware (such as workstation CPUs and their attached storage peripherals, specialized parallel processors), and computational software (algorithms, software libraries, etc.).

3. **Data Base Resources**: Includes specialized data base hardware, storage devices, data base management systems (DBMS), and data bases implemented using these DBMSs.

4. **Communications Resources**: Includes hardware communications devices and interfaces (such as satellite links, modems, local area networks) and software required to communicate over those devices (such as communications drivers, protocols, emulators, and encryption/decryption routines).

5. **Control Resources**: Includes hardware and software required to interface, control, and synchronize the various other resources in ACCE such that they function as a single cohesive environment.

The character of the specific C2 problem or requirement under study will determine how each cited resource will be used. Appendix B provides additional details on each of these resource groups and outlines how they might provide the capability to demonstrate and evaluate advanced technology applicable to the C2 domain.

3.2.3 The Open System Architecture

The ACCE resources will be integrated into an open system architecture. Historically, individual C2 systems have been developed to solve very specific problems within the C2 domain. These systems typically are developed independently by different companies under various sponsoring agencies. Normally, each company takes a different approach to developing solutions. The result is a collection of specialized systems comprised of different architectures, interfaces, hardware and software. This leads to poor interoperability and increased development, training, maintenance and enhancement costs. In response, the government has adopted the Open System Architecture guidelines. An Open System Architecture is a system organization that allows software functions and hardware to be added or deleted without changing the underlying framework. This architecture can be achieved in part by adhering to structured design methodologies that result in modular systems having well defined functions and interfaces. Other considerations are adherence to standards regarding the development language, computer operating system, communications methodology, data base and HMI.

Any software developed for the ACCE and any hardware integrated into the ACCE must conform to Open System Architecture standards. Adherence to these standards will ensure that ACCE resources are generic in nature and can be easily integrated by developers into C2 applications. Specific details on the ACCE Open System Architecture are provided in a separate report.

3.3 ACCE Management Organization

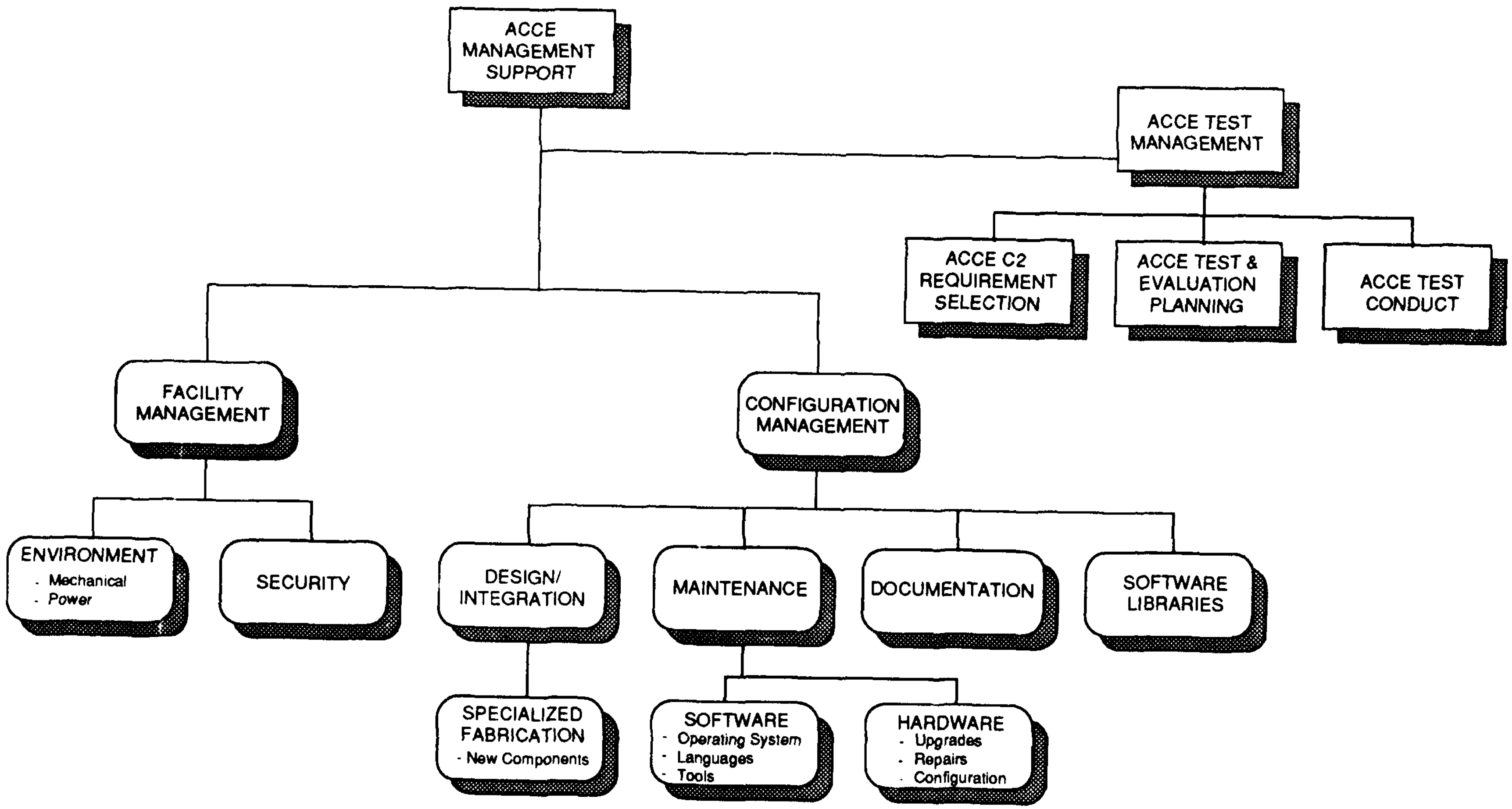
The ACCE management organization provides three primary functions: 1) C2 test management; 2) resource configuration management; and 3) facility management. Figure 3.3-1 outlines the proposed ACCE management organization. The aim of ACCE management is to conduct meaningful research for the Air Force C2 community in the area of display devices and HMI; provide a vision of what ACCE is to become; and to ensure that as ACCE matures and expands, it satisfies near and long term objectives. Specific tasks of management support include:

- Performing operational tests and evaluations of promising display and HMI technologies in response to stated C2 requirements.
- Providing long and short range planning, direction, and guidance to the ACCE throughout its lifecycle.
- Providing the resources to maintain, modify, and where appropriate, expand the ACCE. This includes material (hardware, software, etc.), staff (to perform the activities), and funding support.
- Facilitating the smooth transition of successful technologies from the ACCE to appropriate C2 environments.
- Scheduling and organizing all activities within the ACCE environment.

3.3.1 ACCE C2 Test Management

The primary management requirement is to develop activities that provide evidence of the usefulness of ACCE resources to meet Air Force C2 requirements. This task of C2 test management includes:

- Reviewing, assessing and selecting the C2 requirements to be investigated, and the selection of the ACCE resources for test and evaluation.
- Preparing the pertinent test plans, and establishing measurement and evaluation procedures.
- Coordinating test and evaluation requirements with C2 users, and the ACCE resource configuration and facility management staffs.



ACCE Management Support
Figure 3.3-1

- Conducting the actual test of the ACCE equipment, assessing the test measurement data with respect to the evaluation criteria, and documenting the results.
- Providing an interpretation of the test results that addresses the usefulness of the tested ACCE resources to meet the C2 requirements.
- Obtaining feedback from C2 users concerning desired enhancements to the tested technology.
- Recommending actions to implement successful ACCE technology into the C2 community.

3.3.2 Resource Configuration Management

Resource configuration management gives formal direction and control to the hardware and software resources within the ACCE. The task of configuration management includes:

- Configuring the ACCE to meet the test requirements developed in coordination with the ACCE C2 test management staff.
- Estimating the effort required to perform modifications and additions to the ACCE.
- Assessing the impact that hardware and software upgrades, modifications, and additions have on existing ACCE technology. Often performing an upgrade, while necessary to bring the technology up-to-date, can have an adverse ripple effect on already existing applications.
- Supporting and directing the design, development/fabrication, and integration of new operating systems, applications, and hardware devices into the ACCE.
- Performing routine system backups for software and data on the various systems in the ACCE.
- Performing software and data recovery operations from backups if a system crashes.
- Creation, maintenance, inventory and control of the ACCE Resource Library. This library includes such items as reusable software components, details on emerging HMI, and display technologies and reports of previous ACCE tests and evaluations.
- Creation, maintenance, inventory and control of documentation pertinent to the hardware and software elements within the environment.

3.3.3 Facility Management

Another facet of the ACCE operation involves facility management. This is the management of the physical attributes of the laboratory (i.e., power, heating/cooling, plumbing, structure modification, floor space utilization and physical security). Since the ACCE facility is part of a much larger, already established facility called the C2TC, the responsibility for ACCE facility management will be governed by guidelines established for the C2TC facility. The task of facility management includes:

- Assessing the physical impact of ACCE hardware and software modifications to the combined ACCE/C2TC facility. Facility management will decide how a new hardware resource will be powered, where it will reside in the facility, and who is responsible for maintaining it.

- Establishment and enforcement of access and security procedures and regulations.

Chapter 4

Summary

4.1 ACCE Objectives Summary

The ACCE has been established at Rome Laboratory to isolate and focus Air Force research and development activities that evaluate new HMI and display technologies for the C2 community. ACCE objectives may be summarized as follows:

1. **Create and Exploit Early End User Involvement**: The ACCE will act as a proving ground where candidate technologies may be evaluated before being integrated into advanced development models or even operational systems. In the ACCE laboratory, prototypes ranging from a single display to a complete HMI can be built. This allows a C2 user to provide early feedback to refine or discard a new technology. Another benefit of this objective is that user involvement will promote the development of better C2 requirement definitions. Historically, a major problem in developing C2 systems has been the inability of developers to correctly translate military requirements. By putting the C2 user and the development engineers together, the C2 staffs will learn how to write better requirements and the engineers will better understand the intent of the requirements.

2. **Push C2 into the 21st Century**: The primary driving force behind C2 applications development must be validated user requirements. Analysis of these user requirements remain the basis for selecting relevant technology. However, an objective of the ACCE is to put increased emphasis on selecting high-payoff, state-of-the-art technologies to solve C2 problems, and by that, push C2 into the 21st century.

3. **Focus and Leverage R&D at Multiple Labs**: The ACCE will exploit the technological achievements and resources available at other R&D laboratories to optimize time and money expenditures. External interfaces to these labs promote sharing of technology and resources. Each laboratory can provide expertise or components that, when combined, exceed the technological capabilities of a single lab. For example, a lab specializing in geographic information acquisition and storage may provide the data needed to drive an experiment being conducted by an ACCE researching new methods for geographic data presentation. Distributed C2 experiments also may be conducted among two or more labs to emulate the configurations and architectures of future distributed C2 information and support systems.

4. **Provide a Forum for Cooperation and Integration Among Rome Laboratory Mission Directorates**: Besides interfacing with labs external to Rome Laboratory, the ACCE will interface with the labs within Rome Laboratory. This will stimulate interaction and promote the development of enhanced working relationships among the several directorates.

4.2 ACCE Concept of Operations (CONOPS)

This report provides a concept of operation for the ACCE facility. It outlines how the ACCE staff will examine specific C2 HMI and display requirements, and then identify, evaluate and recommend new technology to satisfy these requirements. This CONOPS document includes: a rundown of the potential users of the ACCE; the interfaces needed to optimize the problem solution; the ACCE task flow concept; an overview of the resources available to the ACCE; and details on the ACCE management organization.

Appendix A

Rome Laboratory Efforts

This appendix provides an overview of three Rome Laboratory efforts and describes how activities conducted within the ACCE could support and benefit them. These efforts are as follows: the Air Defense Initiative Simulation for Command and Control (ADISC2) project; the Survivable Adaptable Planning Experiment (SAPE) program; and the Advanced Planning System (APS) program.

A.1 The Air Defense Initiative Simulation for Command and Control (ADISC2) Project

The Air Defense Initiative (ADI) addresses some previously mentioned situation evaluation requirements at the strategic defense level. The ADI program is investigating and evaluating approaches to an integrated C2 capability to counter the cruise missile and future low-observable advanced technology threats. Although it encompasses the functions of surveillance, engagement, and command and control, the paramount technology thrust is for broad area surveillance, particularly for assured tactical warning and attack assessment. To do this, ADI systems must be able to correlate and fuse multisource data, in real time, to develop an integrated land, sea and air surveillance picture.

The ADI Simulation for Command and Control project incorporates a simulation and prototyping system recently developed under the ADI program. The objective of ADISC2 was to develop an integrated simulation to provide threat, surveillance, engagement and communications models that can be exercised according to approved scenarios. The scenario generation function supports red planning, blue planning and situation definition. The latter function allows the user to alter the scenario by interjecting prescripted events such as intelligence messages.

The ADISC2 simulation hardware architecture in the Rome Laboratory C2TC is comprised of three Sun 3/260 workstations that communicate with each other using the TCP/IP protocol over Ethernet. Each workstation is equipped with a color bit-mapped display, a standard keyboard and a mouse. The HMI is menu driven and graphics oriented, but it was not implemented using the current industry standard for HMI called the X-Window System. The display system allows generation of various 2D and 2 1/2D projections of the earth. The display can range from the size of a state (e.g., Texas, Massachusetts) to the entire globe. The capability also exists to overlay symbols such as ground targets, detonations, missiles, Over The Horizon-B (OTH-B) radar and Space Based Radar. The positions of these point symbols, and the earths position due to rotation, are dynamically updated throughout the scenario.

A.1.1 Candidate ACCE Support Roles for the ADISC2 Program

The ADISC2 program has two primary requirements which make it an ideal candidate for ACCE support. First, most monitoring, targeting and mission planning functions to be supported require a man-in-the-loop. Second, many of these functions make for extensive use of graphics. The cartographic displays are generated from the transformation of coordinates derived from World Data Bank II data files. A preliminary analysis indicates that ACCE experiments could be conducted to gauge the benefits of the technology listed below to the ADISC2 HMI and display functions. These are representative examples only, and represent a small sample of the types of experiments that may potentially be conducted in the ACCE.

- **2 1/2D to 3D Conversion**: Determine whether 3D improves the ADISC2 display as compared to 2 1/2D. This experiment is currently being conducted. ACCE engineers have taken a 2 1/2D view of the globe and added 3D stereo representations of the earth on the Silicon Graphics that include OTH-B and space-based radars. Displays of this nature, particularly those that are dynamically updated whose view can be altered by the user, show great potential to display more realistically the relationships between airborne cruise missiles and the radar coverage area.

- **Use of Large Screen Displays**: The ADISC2 system provides information that the commander and his defense operations staff would require to assess the current cruise missile and air situation. A large screen display or high definition TV device would be extremely useful for this somewhat large audience requirement.

- **Interface Devices**: Integration of devices such as the 3D spaceball will allow the user to point to objects or position objects in 3D space. For example, a function could be implemented that allows the user to select an object in space and obtain its specific characteristics.

A.2 The Survivable Adaptable Planning Experiment (SAPE) Program

During the 1960's, a process was developed to apply nuclear weapons on fixed targets under a single plan to support the US National Policy of Massive Retaliation or Mutually Assured Destruction (MAD). This process of identifying, weaponeering and laying down the forces against these targets is called the Single Integrated Operational Plan (SIOP). It is a planning and replanning activity that can take up to 18 months to develop completely. The system that currently supports SIOP development is called the Triad Computer System (TRICOMS). The TRICOMS has four large mainframe systems: a primary production IBM 3090-300E; a secondary AMDAHL 5890-300 based system used for maintenance of the existing SIOP; a third system, used primarily for development that employs an IBM 3090-600E; and an IBM 3084-QX used for modeling and plan analysis. Although over the years the capabilities of the TRICOMS system have been upgraded, several limitations exist.

The primary objective of the SAPE program is to address the limitations of TRICOM. To do this, the major functions required to generate a SIOP were assessed during the SAPE study. These functions include the following:

- **Target Development**: Selection of desired targets.
- **Desired Ground Zero Construction**: Determination of where the weapon shall impact the target.
- **Weapons Allocation**: Allocation of warheads to the targets.
- **Missile Allocation**: Allocation of vehicles (missiles) to carry the warheads to the targets.
- **Aircraft Allocation**: Allocation of aircraft (sorties) that will carry the weapons to the targets.
- **Time and Deconfliction**: Resolution of missile and aircraft sortie timing, route and warhead detonation conflicts.

Another objective of the SAPE program is to investigate the integration of the following advanced technologies to improve the complete SIOP process and survivability. These include:

- **Distributed Processing**: Offloading some processing requirements to workstations that can provide pooled computer resources for resource load sharing. This technology requires networking and distributed operating system capabilities.
- **Parallel Processing**: Executing complex algorithms in parallel and by that reducing execution time.
- **Knowledge Based Expert Systems**: Providing an adaptive human-computer interface expert system that can control software execution to eliminate process bottlenecks.
- **Distributed Data Base Management**: Providing more efficient data base utilization thus increasing throughput. It can also increase survivability by allowing data to be decentralized.
- **Survivable Multimedia Communications**: Assuring data connectivity through periods of major environmental distress.

The program is currently in Phase II of four phases. The products of Phase II are: Testbed Implementation (FY 4-90); Strategic Relocatable Target Planning (FY 4-90); and SIOP

Maintenance (FY 2-91). The testbed will operate as a loosely coupled distributed system that will share resources to replan the SIOP. Designated testbed sites include Rome Laboratory's C2TC, McDonnell Douglas Corporation, and HQ SAC.

A.2.1 Candidate ACCE Support Roles for the SAPE Program

SAPE could benefit from the application of advanced HMI and display/presentation technology. The SAPE HMI requirements dictate the need for two different types of enhancements. First, SAPE documentation states that a mechanism is needed to screen and reduce the amount of planning situation data to be presented to the analyst. Second, the HMI needs to employ a dynamic, knowledge based, agenda driven schema for high level system control. Both enhancements may use graphics. Current SAPE requirements also call for graphics workstations that employ expert systems technology to enhance the HMI and reduce the operator workload.

ACCE technology evaluations could support the following SAPE functions:

- **Computer-Assisted Planning and Problem Solving**: The complexity of the SIOP generation process could be simplified through the application of graphically-oriented project planning and organizational tools. Although this technology has not previously been addressed in this document, computer-aided planning tools are within the scope of ACCE technology. Many commercial-off-the-shelf (COTS) packages are available that could be evaluated in the ACCE with respect to SAPE requirements. Besides planning, these tools must possess the capability to execute tasks according to previously defined rules. Still, the operator also must be able to monitor progress and override or modify system execution if desired.

- **3D Stereographic Display and Animation**: SAPE functions such as situation monitoring, target development and route planning are candidates for implementation using 3D stereo techniques. Due to the nature of the weapons, the mission planning process is extremely complex. Route planning must consider the electromagnetic effects of nuclear blasts from other detonations. When several thousand targets, many of which are relocatable, are involved, the mission route deconfliction process can be very complex. 3D graphics can be used to review and validate computer generated routes. Additionally, 3D large screen displays may offer analysts the ability to more readily monitor the SIOP execution situation and respond more quickly to enemy threats.

A.3 The Advanced Planning System (APS)

The Advanced Planning System, currently under development, combines the capabilities of several previously developed decision aids into an integrated mission planning tool. Mission planning takes place at the tactical force and unit levels and focuses on the development of mission composition, schedules, and flight plans that follow the directives from the battle planning subfunction. The APS, developed using Air Force Open Architecture Standards, will provide the planner with the automated tools necessary to generate the Air Tasking Order more quickly and efficiently. Data processing capabilities will relieve the operator of many manual administrative paper and pencil type tasks. A dedicated planning data base, developed using a COTS relational DBMS will allow the operator immediate access to friendly force, planning guidance, and environmental information. In addition, interfaces to intelligence data bases will provide the operator with up-to-date target information. An important system component, and a focal point for the ACCE, is the HMI that employs color graphics displays and a mouse driven point and click interface. Graphical display functions allow planning information to be overlaid on a cartographic backdrop. Integrated query functions offer access to expanded information concerning displayed objects from the data base simply by clicking on the object itself.

A.3.1 Candidate ACCE Support Roles for the APS Program

The APS developers realized the value of interactive, visually-oriented tools and therefore, have made extensive use of graphics in this system. Following are some examples of ACCE areas of interest.

- **Graphically Oriented Statistical Displays**: Much of the information retrieved by analysts throughout the mission planning process is statistical in nature, thus it is amenable to representation using graphical displays such as charts and graphs. Available air assets. available weapons, fuel supplies, aircraft capabilities, terrain profiles and installation characteristics are all examples of these types of data. Some of these types of displays are being used in the current APS implementation. Still, additional ACCE investigation may yield new application areas that may be enhanced through graphics.

- **2 1/2 and 3D Cartographic Displays**: Due to the nature of tactical mission planning, many functions are heavily dependent upon geo-referenced information. When selecting optimal flight routes, enemy targets must be plotted, and the offensive and defensive concealment effects of topography and the weather must be considered. Multi-dimensional displays that have been evaluated in the ACCE could make viewing this kind of data more realistic, and by that easier to comprehend by C2 operations planners.

- **Interface to Optical Media**: Optical media such as Erasable Magneto-optical can be used as a data source and to archive data. Digitized imagery and map/charts are readily available on Compact Disk Read Only Memory (CD-ROM) and often can be used in place of cartographic data bases. Although they are static and are incapable of holding feature attributes, they provide a sufficient backdrop for much of the planning data. Furthermore, when used as an archive device, generated missions including graphics can be stored on discs and loaded into computers on board an aircraft. The ACCE provides the perfect environment to evaluate the practicality of these kinds of solutions.

Appendix B

Description and Potential Application of ACCE Resources

This appendix describes each major group of ACCE resources and outlines how they might help in the demonstration and evaluation of advanced technology for the C2 domain.

B.1 Display/HMI Resources

An important technological requirement of any C2 system is the need to display information to the decision makers such as the commander and selected operations personnel, in a manner useful to them. A variety of information must be portrayed, including graphic data such as maps of the area/theater of operations, geographic grid or reference lines, geographical or topographic features, plus many types of textual data including messages, data listings, and reports. Such portrayals represent data on the status of operations in progress, or the location and actions of units, facilities, and equipment related to enemy or friendly land, sea, and air forces.

The human-machine interface (HMI) resources include both hardware and software, and provide the tools that allow a human to interact with the other C2 system components. Interface devices such as mice, keyboards, voice entry and others provide the means to enter data and execute the tasks required to perform the mission. Actual display requirements will vary based on the specific operation and the timeliness of the activity being represented.

B.2 Computational Resources

Computational resources will perform mathematical transactions directly in support of the C2 process. Processes and functions such as data analysis, data fusion, intelligence decision making, image processing, sensor input processing, route planning, target selection, and analysis of enemy and friendly forces are examples of typical functions performed by computational resources in a C2 system.

Computational resources include hardware devices such as the central processing unit of the computer, image processors, array processors, graphics accelerators and floating point accelerators, plus software components such as algorithms, software libraries, and graphic/geographic transformation routines. The processing power of a computer, usually expressed by such measurements as clock speed in megahertz, millions of instructions per second (MIPS) or millions of floating point operations per second (MFLOPS), determines the processing power of a computational resource. Many C2 functions mentioned above are computationally intensive because of the large quantity of the data that must be processed within a short amount of time.

There are several competing C2 needs that will concern the ACCE. First, there is the need for computational hardware, large and powerful enough to perform both the calculations necessary to generate advanced high resolution graphic displays, and still support the remainder of the functions for which the system is responsible. On the other hand, the C2 computational resources must be miniaturized for mobility, and ruggedized for field use. Therefore, the ACCE must investigate more than just the typical computational parameters such as speed, accuracy and reliability. In this regard, parallel and distributed processing technologies may hold the key to providing the required computational power. Instead of increasing the power and size of the individual computers, the possibility exists to distribute the processing load over a network of machines.

B.3 Data Base Resources

The data base resources within the ACCE will provide the data necessary to perform the C2 functions. Data base resources can include data base hardware, such as specialized processors and storage devices. Data base software includes both the data base management systems (DBMSs) and the data bases implemented within those DBMSs. Of interest to the ACCE program are the various data bases and their respective data base management systems, and the technologies which address advanced interfaces to data bases. C2 data bases include:

- Intelligence data base(s) with details on the enemy.
- Friendly Forces data base(s) to provide airfield, aircrew and aircraft equipment, and logistics status data.
- Environment data base(s), to include cartographic and weather data.
- Planning Guidance data base(s) with the commander's guidance, rules of engagement, and operations plans.
- Knowledge data bases(s) also may be available to provide rules for the conduct of selected operations.

The ACCE will be interested in those new technologies that address the processing of large volumes of data base information. This includes technologies that store the data on a single dedicated processor, and those that use a network and a group of processors to provide high throughput of data base information. The data base resource is important because it will provide the information that the ACCE must use for its display and HMI activities.

B.4 Communications Resources

Communications resources are essential elements of the ACCE system. They provide the means to move the data from the data bases to the displays and HMI under investigation. Recent technology advancements have improved many communications characteristics such as speed, accuracy, reliability, vulnerability, anti-jamming, and security. There are also new techniques that allow the uniform communication of data across diverse hardware suites.

ACCE communication resources must not only support distributed processing for computational resources and data base resources, but also must conform to the standards outlined in the Government Open Systems Interconnect Profile (GOSIP). These communication standards include guidelines for most interfaces, including broadband and fiber optic communication networks. In the ACCE, the communications resources must be flexible to allow for rapid configuration of the network for the test and evaluation of the new advanced technologies.

B.5 Control Resources

Control resources are the components of the ACCE -- and a C2 system -- that provide the mechanisms necessary to manage the other resources within the system. They also regulate the flow of information among these resources. Functions performed by control resources include the processing of HMI directives to trigger actions within the system that represent communications, computational, display or data base resource processes. The control resources are responsible for:

- Providing general control of the C2 system.
- Managing the resource manager's processor.
- Initiating and responding to communications requests.
- Activating and monitoring of the computational resources, including identification of the input processing required.
- Regulating display resources so they display information coming from the data base.

Appendix C

List of Acronyms

ACCE	Advanced Command and Control Environment
ADI	The Air Defense Initiative
ADISC2	Air Defense Initiative Simulation for Command and Control
APS	Advanced Planning System
BBN	Bolt, Beranek and Newman Laboratories
C2	Command and Control
C2TC	Command and Control Technology Center
C3	Command, Control and Communications
C3I	Command Control Communications and Intelligence
CD-ROM	Compact Disk Read Only Memory
CO	Command and Control Directorate
COA	Applied Command and Control Systems Division
CONOPS	Concept of Operations
COTS	Commercial-off-the-Shelf Products
CRT	Cathode Ray Tube
DBMS	Data Base Management System
DCA	Defense Communications Agency
DGZ	Desired Ground Zero's

GOSIP	Government Open Systems Interconnect Profile
MAD	Mutually Assured Destruction
MFLOPS	Millions of Floating Point Operations Per Second
MIPS	Millions of Instructions Per Second
HMI	Human-Machine Interface
OTH-B	Over The Horizon-B
R&D	Research and Development
RL	Rome Laboratory
SAPE	Survivable Adaptive Planning Experiment
SGI	Silicon Graphics Incorporated
SIOP	Single Integrated Operational Plan
SON	Statements of Need
TACS	Tactical Air Control System
TRICOMS	Triad Computer System

MISSION

OF

ROME LABORATORY

Rome Laboratory plans and executes an interdisciplinary program in research, development, test, and technology transition in support of Air Force Command, Control, Communications and Intelligence (C^3I) activities for all Air Force platforms. It also executes selected acquisition programs in several areas of expertise. Technical and engineering support within areas of competence is provided to ESD Program Offices (POs) and other ESD elements to perform effective acquisition of C^3I systems. In addition, Rome Laboratory's technology supports other AFSC Product Divisions, the Air Force user community, and other DOD and non-DOD agencies. Rome Laboratory maintains technical competence and research programs in areas including, but not limited to, communications, command and control, battle management, intelligence information processing, computational sciences and software producibility, wide area surveillance/sensors, signal processing, solid state sciences, photonics, electromagnetic technology, superconductivity, and electronic reliability/maintainability and testability.