Research Note 85-97

AD-A161 616

THE ARMY RESEARCH INSTITUTE
UNIT PERFORMANCE RESEARCH AND DEVELOPMENT CENTER

J.L. Fobes

Jet Propulsion Laboratory

for

Contracting Officer's Representative

James H. Banks

ARI Field Unit at Presidio of Monterey

Jack H. Hiller, Chief

TRAINING RESEARCH LABORATORY

Seward Smith, Acting Director

U. S. Army

Research Institute for the Behavioral and Social Sciences

September 1985

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: ARI Research Note 85-97	2. GOVT ACCESSION NO.: AD-A1[illegible]
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): The Army Research Institute Unit Performance Research and Development Center	5. TYPE OF REPORT & PERIOD COVERED: Final Report August 1982 - June 1985
	6. PERFORMING ORG. REPORT NUMBER: --
7. AUTHOR(s): J. L. Fobes	8. CONTRACT OR GRANT NUMBER(s): Contract # NAS7-918, Task Order RE-182, Amendment 244, JPL Task Plan 80-2007
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, CA 91109	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 2Q263743A794
11. CONTROLLING OFFICE NAME AND ADDRESS: U.S. Army Research Institute for the Behavioral and Social Sciences, 5001 Eisenhower Avenue, Alexandria, Virginia 22333-5600	12. REPORT DATE: September 1985
	13. NUMBER OF PAGES: 176
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; unlimited distribution.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

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18. SUPPLEMENTARY NOTES

James H. Banks, contracting officer's representative. A former version of this report has already been published as ARI Research Note [illegible]54. Development of the ARI Unit Performance Research and Development Center

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Jet Propulsion Laboratory
National Training Center
Unit Training
Unit Evaluation

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

This Research Note describes the activities undertaken by the Jet Propulsion Laboratory (JPL) in support of the development of the Army Research Institute Unit Performance Research and Development Center. The description includes the desirability of conducting research with data from the National Training Center (NTC), the requirement for analysis capabilities away from Fort Irwin itself, and the detailed nature of JPL assistance.

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THE ARMY RESEARCH INSTITUTE
UNIT PERFORMANCE RESEARCH AND DEVELOPMENT CENTER

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CHAPTER 1

INTRODUCTION

I. National Training Center (NTC) Overview

II. Research with NTC Data

I. National Training Center (NTC) Overview

Learning to win in the fast-paced, dynamic combined-arms environment requires that Army units be challenged with realistic situations that demand rapid assessments of the tactical situation, timely decision-making, and effective employment of a mix of high firepower weapons. The Army's National Training Center (NTC) at Fort Irwin, California, was established to meet this demand for an intensive combat training environment. At the NTC, battalion-sized armor and mechanized units train in highly realistic live-fire exercises and in force-on-force engagements in which they are confronted by opposing forces (the OPFOR) which have been carefully designed to simulate the Soviet threat. The force-on-force exercises use laser-based, engagement simulation instrumentation technology to provide a degree of realism in real-time casualty assessment second only to actual combat. These exercises involve the full combined-arms operations; that is, tanks, mechanized infantry, artillery, air defense artillery, engineers, Army combat aviation, and close air support. Tactical scenarios were designed to prepare the battalions for critical wartime missions.

The Multiple Integrated Laser Engagement System (MILES) is used on all principal weapons, and casualties are assessed in real-time when a weapon fires and the MILES laser hits a target. "Killed" players are disabled and prevented from participating further in the battle underway (they are "revived" for subsequent battles). In this way, commanders and troops learn the immediate effects of their battle plans and orders using equipment and tactics similar to those of potential battlefield opponents.

Modern micro-miniaturized electronic systems monitor field activities, recording and displaying movements and engagements. Battle actions are later played back for review following both live-fire and force-on-force exercises. In this way, participants are able to see the whole picture—what they were doing and, more importantly, what the enemy was doing. Leaders can analyze the results of their actions—both good and bad—and develop approaches for improvements in the next exercise.

The feedback on both live-fire and force-on-force engagements also form a diagnostic basis for training when the battalion returns to its home station. Take-home packages of exercise data and training recommendations encourage carry-over and reinforcement of the NTC learning experience.

II. Research with NTC Data

Application of modern electronic technologies gives the NTC the capability to support fast-paced training through the use of transparent instrumentation for recording and playing back combat actions. These instrumentation systems are based on micro-electronics, clusters of fast computers, position location systems, and wide screen display technology. Also included is the provision for manually-input exercise data as well as audio and video recordings of critical field action. The bulk of this information is stored in a digitized Player History File for each exercise segment of the overall fourteen day engagement simulation and live-fire exercise.

Now that the NTC's training support components are in place and multi-echelon combined-arms training and evaluation exercises are being conducted on a routine basis, increasing emphasis is being placed on the NTC's potential for addressing questions concerning training techniques, equipment, organizations, and doctrine. The NTC provides a powerful research data base to support such inquiries with data from its instrumented, battalion-level combat field exercises under controlled conditions. This potential shoud be fully exploited since it provides the best source of simulated combat and task force training data routinely generated. When fully developed, a NTC data analysis methodology will provide the essential complement to the Army's exploitation of high technology training and should provide the Army with a decided skill-based advantage over its adversaries.

Since the inception of the NTC concept, senior command directives have specifically dictated that the primary mission of the NTC is to serve as a combat training support facility, rather than as a combat proving ground or research center. These directives have been reinforced by clearly defined policies which delimit on-site research teams and preclude modification or adaption of training scenarios to support studies or experiments. While the NTC was conceived to only provide realistic experiential unit training for armor and mechanized infantry Battalion task forces, an important byproduct of such unit training is the exercise history data generated at the NTC. These data may contribute to a powerful research data base which can be used to support training technology research and be used to study issues of tactics, doctrine, organization, and equipment effectiveness. Of course, any research efforts associated with the NTC must be based on capturing available NTC data and transporting it to sites where the desired research can be conducted with no interference with the NTC training mission.

The U. S. Army Research Institute (ARI) initiated a program to enable it to make timely and effective use of NTC data in support of ARI's full spectrum of research efforts directed towards improving unit combat performance. However, before ARI could be in a position to pursue such research, it was necessary for ARI to possess the elaborate equipment and facilities necessary to examine and manipulate NTC-generated data. Since a substantial portion of this preparatory phase consisted of the overall system architecture design required to systematically use NTC data for research, the expertise of the staff at the Jet Propulsion Laboratory (JPL) was obtained pursuant to the agreement in Appendix A (Memorandum of Understanding Between the U. S. Army and the California Institute of Technology [CALTECH] concerning the Jet Propulsion Laboratory [JPL]).

CHAPTER 2

JPL SUPPORT OF ARI NTC RESEARCH
PHASE I: SYSTEM DESIGN AND PROCUREMENT

I. Overview

After considerable discussion of the nature of the facilities required to provide the capability to analyze NTC data, ARI and JPL entered into its initial support agreement (Appendix B: Army Research Institute Training Research and Development System Proposal Number 80-1927, 22 June 1982). This agreement outlined the preliminary nature of JPL's effort and accompanying contractual agreements to effect that effort.

JPL then developed an overview task plan to guide their overall effort on behalf of ARI research (Appendix C: Training Research and Development System Task Plan [for Phase I through Phase IV], 1 July 1982). This task plan provided for support of both ARI's long and short term goals. Overall objectives consisted of JPL support to:

- o Help establish an ARI research capability to enable analysis of Army unit training data from the NTC, and from other sources as appropriate;
- o Provide long-term technical support to ARI on various aspects of training evaluation and research issues.

The immediate objectives of JPL's support effort were to:

- o Design, procure, install, and make operational the basic computer system required;
- o Design and develop the facility site to properly house the system.

II. Implementation

As specified in their task plan, JPL then prepared an implementation plan to accomplish ARI's immediate research needs (Appendix D: Phase I Implementation Plan, 26 September 1982). This plan provided for task management, system integration, as well as hardware and software procurement to provide ARI with a system, fully compatible with that at NTC, to store and replay NTC data. Activities included:

- o System requirements definition and design;

- Procurement of hardware and software elements required to examine NTC data;
- Integration of the procured elements into an operational system;
- Site development at the ARI Field Unit at the Presidio of Monterey (POM) to support the Training Research and Development System; and
- Formulation of a Task Plan for Phases II and III of the Training Research and Development System.

It should be noted that ADP equipment procurement was preceded by JPL compliance, through their parent organization--NASA, with the provisions of the Brook's Amendment (Appendix E: ADP Equipment Acquisition Plan, 25 August 1982).

The recommended computer items ultimately procurred are depicted in Figure 1. In addition, JPL also prepared the facility site development plan necessary to house this equipment and then assisted ARI with its implementation. JPL work included: (1) specification and installation of raised computer flooring; (2) specification and installation of air-conditioning units; (3) specification of electrical requirements and power distribution; and (4) specification of remote diagnosis telephone lines, and (5) specification of alterations in the four rooms involved in site development.

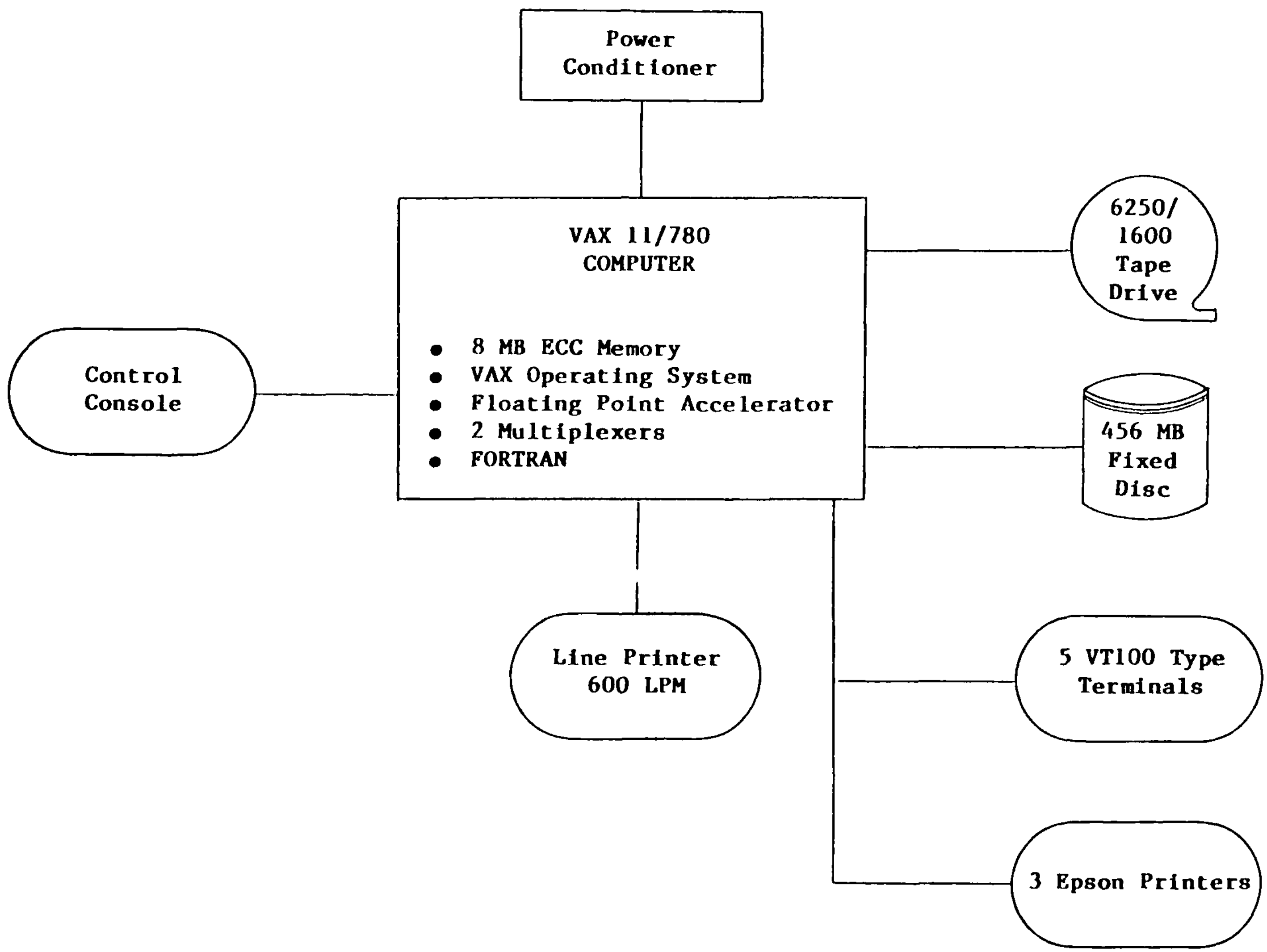

Figure 1

Computer Configuration

CHAPTER 3

JPL SUPPORT OF ARI NTC RESEARCH
PHASE II: DATA DISPLAY AND CONTROL SUBSYSTEM

The equipment and facilities depicted in Figure 1 represent the core analysis system required to conduct research with data from the NTC. In addition, as indicated in the Phase II Task Plan (Appendix F: Training and Development System Phases II and III, 30 Aug 82), it was necessary to expand the basic system to provide for data retrieval and display in the NTC format. This elaboration consisted of two support activities that were accomplished through JPL by a subcontractor in response to JPL's Statement of Work (SOW) in Appendix G (Display and Control Subsystem for ARI-POM TRADS, 20 May 83). This SOW indicated the work necessary to procure, fabricate, assemble, deliver, install, and make operational the Display and Control Subsystem of the ARI Training Research and Development System. This requirement was met in part by the two NTC controller stations, depicted in Figure 2, designed to permit manipulation and display of NTC data. The complete system is itemized in Appendix H (Final NTC R&D Comuter Center Equipment List, August, 1984).

In addition, a substantial amount of operational software was delivered. This software consisted of the NTC Interactive Display and Control software developed for the 500 Player NTC Instrumentation System that was recovered and modified for ARI. The software is capable of reading and causing to be displayed the following NTC data: position/location and firing event data (direct and indirect), communications keying event data, and all other data currently maintained to generate NTC alphanumeric and graphic displays. The software is also capable of simultaneously driving the two Display and Control Stations from the same or different NTC exercise History Data.

The final JPL product in support of NTC data display and control was their study of the utility, creation, and use of a large-scale NTC research data base (Appendix I: Considerations in the Establishment and Use of a Research Data Base for Analysis of Army Training, 4 February 1983). This document reported their recommended systematic approach to the definition and use of a research data base, as well as the identification of the criteria for the selection of a data base management system.

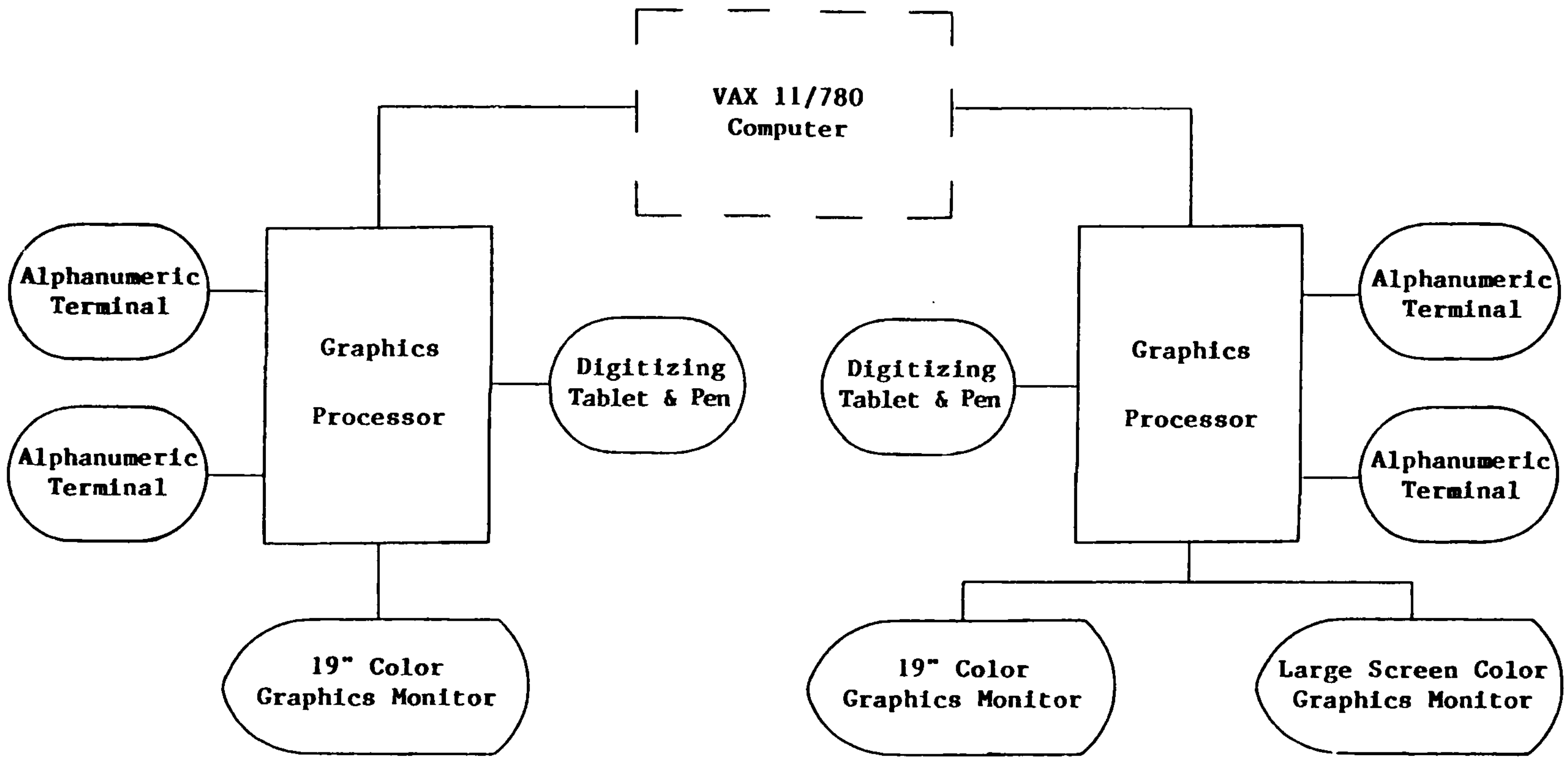

Figure 2

Controller Stations Configuration

APPENDIX A

Memorandum of Understanding Between the U. S. Army

and the California Institute of Technology (CALTECH)

Concerning the Jet Propulsion Laboratory (JPL)

May 1982

APPENDIX A

Defense Programs Office

Memorandum of Understanding Between the U.S. Army and the California Institute of Technology (Caltech) Concerning the Jet Propulsion Laboratory (JPL)

May 1982

National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

MEMORANDUM OF UNDERSTANDING

BETWEEN THE

U. S. ARMY

AND THE

CALIFORNIA INSTITUTE OF TECHNOLOGY (CALTECH)

CONCERNING THE

JET PROPULSION LABORATORY (JPL)

CONTENTS

1.0 PURPOSE

The purpose of this MOU is to describe and document the general agreements to establish a long term relationship between the Army and the California Institute of Technology's (Caltech) NASA-sponsored Jet Propulsion Laboratory (JPL). JPL shall perform only such work as shall be authorized and required under contractual task orders issued by NASA or under direct contracts between the Army and Caltech. This MOU is not intended to affect in any way the rights and obligations of the parties under any such task orders or contracts.

2.0 BACKGROUND

Throughout the 1940's and 1950's, the U.S. Army and Caltech developed JPL into a key resource for guided missile research, development, and project implementation. After JPL was transferred from the U.S. Army to NASA in 1958, NASA and Caltech have made major advances in the development of this national resource. JPL's role for over three decades has been to conduct technology developments and incorporate them into some of the nation's most challenging systems applications by means of its project implementation skills. During the last two decades, JPL has played a principal role in the development and operation of every U. S. automated mission to the moon and planets. These forty-some missions by their nature have involved high technology at both the system and component level. Incorporated within those spacecraft were many technological advances of great interest to the DOD. Now as the civilian space program enters a phase of emphasis on utilization of the shuttle capability, NASA planning calls for some reduction in automated missions to the moon and planets. As a consequence, JPL with support of NASA is prepared to commit a significant portion of its technical staff to assignments from the Department of Defense. At the same time, the U.S. Army has initiated several thrusts to expedite the application of the most advanced technology into a coherent set of operational systems to carry out its mission. Thus, an opportunity has been provided for an enduring relationship through the merging of interests of the U.S. Army and NASA.

3.0 JPL MISSION AREAS

With this MOU it is intended to establish a relationship wherein JPL evolves into a key Army resource for research and development. Mission areas wherein JPL can be expected to play a key role in years to come include:

- Provide for a major activity for the Army in highly autonomous and fault-tolerant machines in response to the Army's thrust in brilliant missiles and pilotless flight systems;

- Provide for a major activity for the Army in its thrust in very intelligent surveillance and target acquisition systems;

- Participate in selected activities for the Army in survivable and efficient information systems with attention to the meta-system involving several of these in association with appropriate Commands and laboratories as a response to the Army's thrust in distributed C^3I; and

- Participate in selected activities for the Army in training and simulation systems in association with appropriate Commands and laboratories within the Army.

4.0 CHARACTERISTICS OF THE JPL MISSION

4.1 From time to time JPL may perform selected tasks for the Army which do not fall within the above described roles.

4.2 Response to Assigned Work

JPL will award its roles for the Army a priority as high as any role that JPL performs for other parts of the Government. It will assure an equitable application of key staff to Army assignments and provide a stability of key staffing commensurate with that provided to other Government assignments.

4.3 Accountable Work Assignments

Within the above selected roles, it is the Army's intent to make assignments to JPL for the accountable management and implementation of:

1) feasibility or test-bed demonstration projects which are aimed at follow-on, full-scale engineering demonstrations and orderly transitions into the Army's industrial base (see Section 4.5 for additional detail); and

2) a base of ongoing research and technology tasks to support these projects (see Section 4.6 for additional detail). It is estimated that this base will comprise about 25% of the total Army effort at JPL.

4.4 Support Assignments

In addition to responding to project and technology assignments, JPL will provide some level of assessment, system engineering, and technical advisory support to Army Project Officers on selected projects for which JPL has not been assigned accountable management or implementation (see Section 4.7 for additional detail).

4.5 Accountable Project Assignments

4.5.1 The Army recognizes that JPL, as a part of Caltech, must be a technical doing organization that is responsible for making end-item deliverables and that JPL's strengths have been derived from prior assignments to: 1) design, integrate, and operate entire automated flight systems; 2) develop end-to-end information systems including the supporting networks, and 3) work on a broad spectrum of research, and technology tasks. In this context, the Army envisions that JPL will fulfill one or more active accountable project roles throughout the duration of this relationship.

4.5.2 JPL's Project Assignments during feasibility and fullscale engineering development (FSED) phases are expected to include areas of responsibility such as tradeoff studies, preliminary design, objective costing, system engineering, subsystem integration engineering, first-prototype fabrication, systems integration, systems test, and systems demonstration. As part of these assignments, JPL may subcontract to industry for portions of the work to be performed as necessary.

4.5.3 JPL recognizes the importance to the Army of transferring technological understanding and designs to the Army industrial community and to its field user Commands. Therefore, JPL will utilize industrial capabilities to the fullest reasonable extent in performing its assignments and will perform the necessary functions to effect an orderly transition of developments into the Army's industrial base for production, deployment, and into field use operations.

4.6 Research and Technology Base

In order to effectively perform accountable project assignments and support assignments, it is important for JPL to perform within its principal roles, a broad set of research and technology development tasks.

These task efforts, which are expected to be about 25% of the total Army effort at JPL, will occur in such fields as:

- Highly autonomous systems;
- End-to-end information systems and technology;
- Very large scale integrated circuit technology and application;
- Remote sensing instrumentation, sensor, and data systems;
- Navigation;
- Guidance and control technology;
- Teleoperator technology;
- Power and propulsion technology;
- Telecommunications and position location; and
- Materials and structures.

4.7 Support Assignments

The JPL expertise, to be further developed by the Army, through JPL's performing accountable project and research and development assignments, may be brought to bear on other Army needs in the form of support assignments.

These support assignments include:

1) supporting the Army in its advanced battlefield systems concept and technology development programs;

2) performing system engineering and technical advisory (SETA) roles for selected Army Project Offices.

5.0 MISSION SCOPE

The scope of the JPL mission for the Army is determined by its prior commitments to other Government Agencies. The Caltech-NASA MOU limits the level of work to be performed by JPL for other agencies. Consequently, it is understood that the ceiling on the number of direct-charging members of the JPL staff applied to Army assignments for now could be in the range of 250-300 direct workyears per year. Indirect charging members of the JPL staff would add proportionately to these workyears.

The Army is not obligated to fund that level of staffing nor is the survival of JPL as an institution dependent upon the Army.

The Army intends to be concerned with the viability and continuity of assignments for JPL. As a means of managing the scope of the JPL mission, a joint Army/JPL planning activity will be established and maintained to:

1) plan the stable application of the JPL staff to achieve a continuous flow of appropriate assignments within the limits of staff availability;

2) plan assignments to JPL in the areas of greatest interest to the Army;

3) establish appropriate procedures to assure that only efforts requiring the special competence of the JPL staff are proposed as contractual tasks; and

4) plan the appropriate mix of work assignments between accountable projects, accountable research and development tasks, and support tasks.

6.0 MANAGEMENT ARRANGEMENTS

6.1 MOU Oversight and Planning

A designated deputy in the Office of the Assistant Secretary of the Army for Research, Development and Acquisition (OASA(RDA)), and a manager reporting directly to JPL's Assistant Laboratory Director for Defense Programs, will jointly oversee the relationship to meet the spirit of this MOU.

Those individuals will co-chair a Planning and Review Committee comprised of appropriate Army Commands, Army Advisors, and the JPL management, to develop the scope and content of the JPL mission as addressed in Section 5.0.

The Planning and Review Committee will conduct a ..rformance review and planning activity at least annually.

6.2 Program Manager Relationship

The JPL Program Manager for Army programs will attend, as requested, and participate in appropriate Army Program Management Reviews. It is intended that JPL be considered to be an Army resource, but with neither the Army nor JPL relinquishing control of identity or mission.

6.3 Planning

The Planning and Review Committee will prepare and revise annually a plan to guide the JPL efforts.

The relationship must be flexible and responsive to a dynamic environment so the actual year-to-year work may necessarily deviate from the plan.

6.4 Access and Reporting

6.4.1 JPL will ensure that the Office of the Assistant Secretary and the appropriate Army commanders will have access to JPL upper management regarding JPL's performance on work being done for those Commands.

6.4.2 JPL's Defense Programs Office will report to the Office of the Assistant Secretary on its progress and resource utilization. Since most project and task assignments will be derived from subordinate Commands within the Army or DARCOM, regular reports will be made to the appropriate Project Officers within those Commands. At any time, JPL will provide the Army with complete access to detailed information on all activities being performed by JPL for those Commands.

6.5 Review

A preliminary written draft evaluation of JPL's performance on all project, task, and support assignments performed during a year will be sent by the Office of the Assistant Secretary to JPL for comment. JPL will suggest changes to this draft if appropriate. The Office of the Assistant Secretary will then utilize the finalized evaluation report in a face-to-face performance evaluation of JPL in a meeting with JPL upper management, including the President of Caltech. Appropriate personnel from NASA will be invited to these reviews to assess general compatibility with NASA programs and interests. JPL will take corrective actions in response to the performance evaluation as appropriate.

7.0 ADMINISTRATIVE CONSIDERATIONS

7.1 Conformance to NASA-Caltech MOU

The 1978 Caltech-NASA MOU (Section 7.2) states that "NASA will encourage JPL efforts to organize and acquire non-NASA work around long-term programmatic or technological thrust . . . and seek responsibility for coherent programs or projects in contrast to accumulating a large set of diverse and unrelated tasks."

7.2 Contracting

7.2.1 JPL shall perform work for the U.S. Army as authorized and required under contractual tasks orders issued by NASA for the Army.

7.2.2 Nothing in this MOU shall preclude a direct contract between the Army and Caltech. In the foreseeable future, NASA will continue as the prime sponsor of JPL and the Army will utilize the prime contract NAS 7-100 as the means to sponsor work at JPL. Therefore, the cost of work done by JPL for the Army will be reimbursed to NASA through the standard interagency reimbursable method.

7.2.3 In accordance with the 1978 Caltech-NASA MOU this work shall fall in that category where "NASA makes no programmatic commitment . . . " Consistent with the intent of that MOU statement, it is expected that NASA will assure that the administrative arrangement will permit the Army to maintain technical direction and management of the JPL effort without any intermediate management functions.

7.3 Security

7.3.1 JPL is prepared to provide to the Army reports, hardware, and software deliverables with security classifications as high as Top Secret. JPL will take the necessary steps to clear the JPL staff performing Army assignments as well as their management and Review Boards.

7.3.2 Open access to JPL in general will remain in accordance with existing JPL procedures. Access to offices, laboratories or other facilities where classified work is ongoing will be restricted in accordance with appropriate Defense Investigative Services Clearance Office (DISCO) procedures.

7.3.3 In selected instances, the Army may choose to involve JPL in special access matters. If such a need arises, the Army will support the obtaining of any needed special access clearances and will support JPL's need to provide one or two on-Lab rooms for dealing with special access topics. If necessary, JPL will arrange for special access facilities at sites other than JPL.

7.3.4 Should JPL perform any staff work with a special access nature, the actual deliverables, analyses or study results will bear the signature of the Army officer within the appropriate Army Command who will be accountable for the character and quality of the work.

8.0 EFFECTIVITY

Both parties view this association of JPL and the Army as an ongoing relationship for many years. This MOU will be reviewed in one year to incorporate the results of the effort described in paragraph 6.1.

For the U. S. Army:

ORIGINAL SIGNED BY

J. R. Sculley
Assistant Secretary of the Army (RDA)

Date: 1 April 1982

ORIGINAL SIGNED BY

James R. Ambrose
Under Secretary of the Army

Date: 12 May 1982

For Caltech:

ORIGINAL SIGNED BY

Bruce Murray
Director

Date: April 1, 1982

ORIGINAL SIGNED BY

Marvin L. Goldberger
President

Date: 1 April 1982

JPL
JET PROPULSION LABORATORY
California Institute of Technology
4800 Oak Grove Dr. / Pasadena, CA 91109

ADP EQUIPMENT ACQUISITION PLAN

AP. 453

August 25, 1982

(Date)

Army Research Institute
Training Research and Development System

(Descriptive Title)

A. G. Silliman

(Prepared By)

ABSTRACT

The Jet Propulsion Laboratory is supporting the Army Research Institute for the Behavioral and Social Sciences in the development of a research capability which will be used to study Army unit training. This ADPE Acquisition Plan which covers Phase I of the task, is for the procurement of the computer and associated ADPE equipment for this research capability.

The Army Research Institute will utilize data obtained at the National Training Center located at Fort Irwin, California. In order to study this data, the Army Research Institute must install the identical control center configuration as exists at the National Training Center, to simulate operations, utilize already developed programs and to write new programs for their use. Thus, this plan specifies the acquisition of a Digital Equipment Corporation VAX-11/780 system and peripheral devices. The system cost is estimated to be $343,800 and will be procured competitively. The system life is expected to be over eight (8) years, since the National Training Center upgrade is not expected until the 1990's.

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1. INTRODUCTION

The National Training Center (NTC) at Fort Irwin, California, provides the most realistic training available to a modern peacetime army. Consequently, the NTC has the potential for greatly improving the training of maneuver arms battalions, thereby enhancing the training component of combat readiness. For this potential to be fully realized, there is a critical need to develop new research capability and analytical tools to profit from the massive amounts of data collected during NTC operations. This capability is necessary to support both the current NTC Phase I operations and refinements as well as the future design of the NTC Phase II system. Key areas in need of improvement include performance measurement and diagnosis, training information display and feedback, and tactical operations analysis. Further, unit training must be considered as a total integrated system; NTC and home-station training practices must both be considered when designing systems for improving the proficiency of tactical units. Finally, NTC-generated data will be important for research on issues beyond unit training and training management. The new research capability must be able to support diverse Army R&D priorities ranging from problems in manned-systems integration to problems in personnel acquisition, assignment, and retention.

This research will be performed by the Army Research Institute Field Unit at the Presidio of Monterey (ARI-POM), California. This Field Unit has the mission within ARI of conducting research on unit training and performance measurement. In order to carry out this mission, ARI requires a Training Research and Development System which is fully compatible with that developed for the NTC and which can expand to permit extensive off-line analyses of data recorded during NTC training exercises.

This system will be installed at ARI-POM California. Site preparation support will be given to ARI. JPL will be responsible for the implementation of the system, which includes the installation of the equipment, installation of the software, integration of any upgrade and maintenance of the system during the 2 1/2 years of the task. Thereafter, the system will be transferred to ARI.

In subsequent phases of the task, JPL will develop the capability for ARI to organize and use the vast amount of data that is acquired at NTC. A comprehensive data base management system will be developed to allow for efficient usage of the simulated battlefield acquired data. Additionally, investigations will be made into the use of three dimensional computer graphics to improve NTC displays. Other data base utilization, such as line-of-sight algorithms for Fort Irwin, California will also be investigated. JPL, with its background in data base systems and computer graphics, is well suited to provide ARI with the required research support.

II. FUNCTIONAL REQUIREMENTS

JPL will support the implementation of the ARI Training Research and Development System as well as developing of tools to utilize the NTC data.

The procurement of the computer system for the Training Research and Development System which will be installed at ARI-POM is the principal component of the initial phase of the task to spport ARI. This system must be compatible with the existing DEC VAX 11/780 computer system at NTC to take advantage of the software developed for NTC use, and to enable the creation of new software that can be used by NTC.

The equipment list presented in this plan is the Phase I procurement items. A study will be performed during this Phase I to determine the exact additional equipment to fulfill the ARI mission needs.

Special NTC equipment as well as expanded system needs for research will be examined. The additional equipment if required will be procured during Phase II of this task. A new ADPE acquisition plan or a revision to this plan will be developed depending upon the outcome of the study.

III. ALTERNATIVES CONSIDERED

Because of the requirement that the system be an exact copy of the NTC VAX system, the use of a VAX based computer system is a necessity. Because of the requirement that the system be installed at ARI-POM, California this precludes the use of any system at JPL.

An examination of GSA, NASA and JPL surplus ADPE lists indicates that there is no available ADPE equipment that meets the requirements of this plan.

IV. PROPOSED SYSTEM

The required ADPE system must duplicate a subset of the existing NTC computer configuration. The NTC system has multiple Digital Equipment Corporation VAX 11/780 computer systems. The required Training Research and Development System configuration is shown in Appendix B and the ADPE components are listed in Section VI.

V. JUSTIFICATION

JPL has undertaken the task to assist ARI in the development of training research and development mission. JPL is required to provide and implement the baseline computer system in the exact configuration as currently is used in NTC. In order to accomplish this implementation, JPL must procure the computing equipment listed in this Plan.

VI. ADP EQUIPMENT LIST

Item #	Qty	Item Model #	Functional Description	Purchase Price	Monthly Lease Rate	Monthly Maint. Rate
1.	1 ea	DEC SV-AXVCA-CA	VAX-11/780 CPU 2MB ECC MOS Memory 516 MB Fixed Disk Drive with MBA 6250/1600 b/in Tape Transport with MBA 8 line Asynchronous Multiplexer Console Terminal VAX/VMS Operating System	$300,000	$ 12,000	$ 1,121
2.	1 ea	DEC FP 780-AA	High-performance Floating Point Accelerator	$ 11,200	$ 448	$ 50
3.	1 ea	DEC LXY21-SY	132-column, 96-character dot matrix printer and plotter with control unit	15,800	1,264	163
4.	1 ea	DEC MS780-DD	2 MB ECC MOS expansion memory	13,000		294
5.	1 ea	DEC VT125-AA	Extended Alphanumeric Video Terminal with Data Plotting Extensions. Bit Map Graphics, Automatic vector and curve generation	3,800	152	29
		Total		$343,800	$ 13,864	$ 1,363

VII. UTILIZATION

The anticipated period of use of this equipment is until 1990 after which an upgrade is possible in support of the next generation NTC. Utilization is expected to be about 8 hours per day, 5 days per week. The work load is expected to be divided among various efforts in programming and operational analysis.

Projected Workload:

Science and Engineering:	50%
Data Reduction:	25%
Simulation:	25%

VIII. LEASE vs PURCHASE ANALYSIS

N = 96 months

Purchase Cost = P + M + I

P = Basic Purchase Price	=	$343,800
M = Maintenance Costs (96 months) x ($ 1,363)	=	130,848
I = Interest Costs (14%) x ($343,800) x (96+12)/24	=	216,594
Total Cost to Purchase	=	$691,242

Lease Cost = L + M + T

L = Basic Lease Cost (96 months) x ($ 13,864)	=	$1,339,944
M = Maintenance not included in L (96 months) x ($ 1,363)	=	130,848
T = California Use Tax *		----------
Total Cost to Lease	=	$1,461,792

* Lease cost used for GSA schedule and does not include state use tax

This analysis indicates that the least cost option is to procure the specified system.

IX. PROCUREMENT METHOD

This system is proposed to be procured as a competitive procurement. The procurement, however, must provide to ARI the exact configuration as currently utilized by NTC. The sole source specification justification for the Digital Equipment Corporation VAX 11/780 computer system is attached to this plan as Appendix D.

This procurement will provide the initial Training Research and Development System. Procurement method for any future equipment requirement will be determined at that time.

X. FUNDING SUMMARY

The funding will be wholly from Account Code #735-60203-0--8300.

JPL will procure the system in FY82, install it in FY83, maintain the system through the first half FY85 and transfer all activities to ARI at the conclusion of the task on April 1, 1985.

	FY82	FY83	FY84	FY85
Acquisition Costs				
Purchase	$343,800	$ -0-	$ -0-	$ -0-
Burden Cost	53,633			
Total Acquisition Cost	$397,433	$ -0-	$ -0-	$ -0-

	FY82	FY83	FY84	FY85
Operational Costs				
Maintenance	$ -0-	$ 13,360	$ 16,356	$ 6,815
Installation*	-0-	-0-	-0-	-0-
Site Preparation Equipment	90,000	-0-	-0-	-0-
Burden Cost	14,040	2,126	2,552	1,063
Total Operational Cost	$104,040	$ 15,756	$ 18,908	$ 7,878
Total Planned Cost	$501,473	$ 15,756	$ 18,908	$ 7,878

* Included in the purchase price.

XI. ASCII COMPATIBLE

This system is to be fully ASCII compatible. No exemption is requested.

XII. IMPLEMENTATION SCHEDULE

Acquisition Plan approved	14 Sept.,1982
Purchase Order issued	18 Oct., 1982
Facility Preparation completed	17 Dec., 1982
Equipment Delivered	17 Dec., 1982
Equipment Operational	7 Jan., 1983
Equipment Transfer to ARI	1 Apr., 1985

XIII. JPL AUTOMATIC DATA PROCESSING PLAN REFERENCE

The proposed acquisition does not appear in the JPL 1984 ADP Plan, dated 14/Aug/1982, but will appear in all future issues as part of NASA/GSA FMC 74-2 System NC-55-07-TR, JPL ADPAR Index 07-67.

XIV. FACILITY DESCRIPTION

The VAX-11/780 will be installed at a facility at ARI-POM, California.

Facility preparation will include; power conditioning, power distribution, environmental conditioning and computer flooring. ARI has designated the building and rooms that will be modified to support the system.

The estimated facility preparation cost is $90K which includes the cost for power conditioning, power distribution, environmental conditioning and flooring.

XV. SECURITY PROVISION

The facility is located at the Presidio of Monterey, in Monterey, Caifornia a U. S. Army facility. Access to the facility is controlled. The facility contains an inner office that will be used for software media storage. Also, JPL will house at JPL Pasadena, a duplicate set of all software provided by JPL during the duration of this task for backup purpose.

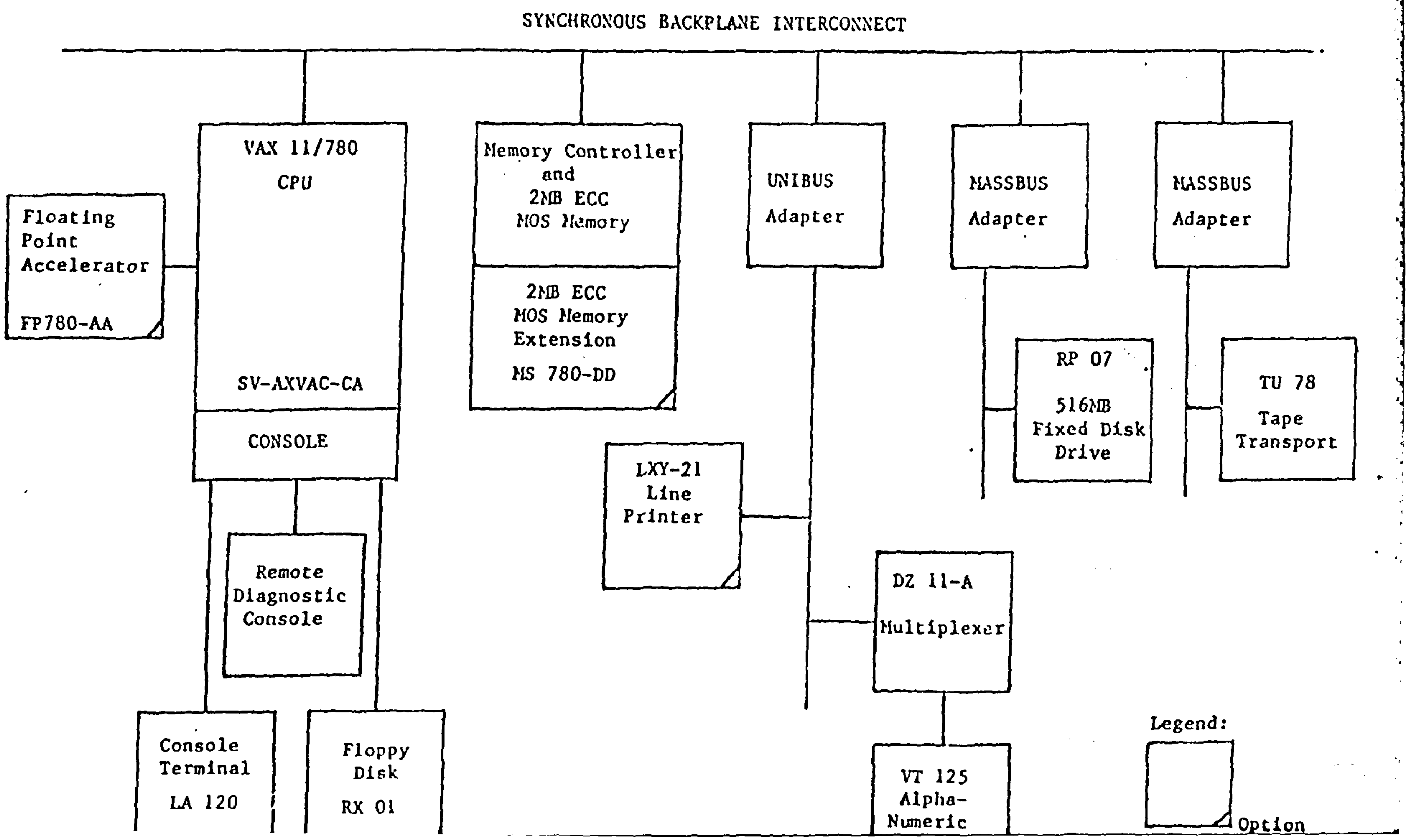
XVI. APPENDIX

A. Glossary of terms

ADPE	Automatic Data Processing Equipment
ASCII	American Standard Code for Information Interchange
ARI	Army Research Institute
b/in.	bits per inch
DEC	Digital Equipment Corp.
JPL	Jet Propulsion Laboratory
MB	Mega Byte
NTC	National Training Center, Fort Irwin, CA
POM	Presidio of Monterey

ARMY RESEARCH INSTITUTE (ARI) TRAINING RESEARCH AND DEVELOPMENT SYSTEM

PHASE I BLOCK DIAGRAM



APPENDIX B

Army Research Institute Training Research and Development System

22 June 1982

Appendix B

ARMY RESEARCH INSTITUTE
TRAINING RESEARCH AND DEVELOPMENT SYSTEM

to the

Army Research Institute
for the
Behavioral and Social Sciences
5001 Eisenhower Avenue
Alexandria, Virginia

Proposal Number 80-1927

June 22, 1982

Prepared by:

A. G. Silliman
Task Manager

Prepared by:

C. E. Herberger
Contracts Management Office

Approved by:

J. N. James
Assistant Laboratory Director
for Defense Programs

JET PROPULSION LABORATORY
California Institute of Technology
Pasadena, California

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I. TECHNICAL

A. Background

The National Training Center (NTC) at Fort Irwin, California, provides the most realistic training available to a modern peacetime army. Consequently, the NTC has the potential for greatly improving the training of maneuver arms battalions, thereby enhancing the training component of combat readiness. For this potential to be fully realized, there is a critical need to develop new research capability and analytical tools to profit from the massive amounts of data collected during NTC operations. This capability is necessary to support both the current NTC Phase I operations and refinements as well as the future design of the NTC Phase II system. Key areas in need of improvement include performance measurement and diagnosis, training information display and feedback, and tactical operations analysis. Further, unit training must be considered as a total integrated system; NTC and home-station training practices must both be considered when designing systems for improving the proficiency of tactical units. Finally, NTC-generated data will be important for research on issues beyond unit training and training management. The new research capability must be able to support diverse Army R&D priorities ranging from problems in manned-systems integration to problems in personnel acquisition, assignment, and retention.

This research will be performed by the Army Research Institute Field Unit at the Presidio of Monterey (ARI-POM), California. This Field Unit has the mission within ARI of conducting research on unit combat training and has long conducted research on unit training and performance measurement. In order to carry out this mission, ARI requires a Training Research and Development System which is fully compatible with that developed for the NTC and which permits extensive off-line analyses of data recorded during NTC training exercises.

A three phase implementation approach is required by ARI in the development of this system. Each phase will result in an operating version of the ARI Training Research and Development System having a specific set of functional capabilities. Users and system developers will evaluate the capabilities of each operating version to determine system deficiencies and limitations. These evaluations will be used to update the user requirements for the system, and they will serve as the basis for evolving the system functional capabilities for the next version. Each successive version of the system will possess a greater degree of capabilities consistent with user requirements.

In summary, the phased system requirements are:

Phase I. The capability to examine NTC training data.

Phase II. Simulation of the NTC data processing and review functions for off-line performance measurement analysis.

Phase III. A data base system to provide capability for broad analysis and use of NTC data.

B. Jet Propulsion Laboratory's (JPL's) Objective

JPL's objective is to provide ARI with a Training Research and Development System which they will use to carry out the research and development mission as set forth above.

C. Approach

1. JPL's Role

JPL, in support of ARI, will provide the task management, procurement, and systems integration necessary for the implementation of the three-phased ARI Training Research and Development System.

2. Phase I System Implementation Approach

This proposal addresses only Phase I of the Training Research and Development System. Areas of concentration by JPL during this phase will be:

a. Procurement of hardware and software elements of required to examine NTC data.

b. Integration of the procurred elements into an operational system.

c. Site development at the ARI-POM to support the Training Research and Development System.

d. Formulation of a Task Plan for Phases II and III of the Training Research and Development System.

The basic computer system to be considered for Phase I will consist of the following items or equivalent:

Quantity	Make/Model and Description
1	DEC VT125-AA Graphic Video Terminal
1	DEC SV-AX VCA-CA System
1	DEC QE100-AY VAX-11 FORTRAN
1	DEC FP780-AA Floating Point Accelerator
1	DEC LXY21-SY 600 LP Printer
1	DEC MS780-DD 2MB ECC Memory
1	Power Conditioning Unit
1	Environmental Control Unit
	Computer Flooring

3. Phase I Work Breakdown Structure

Three (3) units have been identified. These are:

a. Task Management

This work unit provides the management, control, scheduling, and coordination required to conduct this task. The Phase I Implementation Plan, the Task Plan for Phases II and III, and periodic reports are also provided under this work unit.

b. Systems Integration

This work unit provides for the integration of the hardware and software into an operational system.

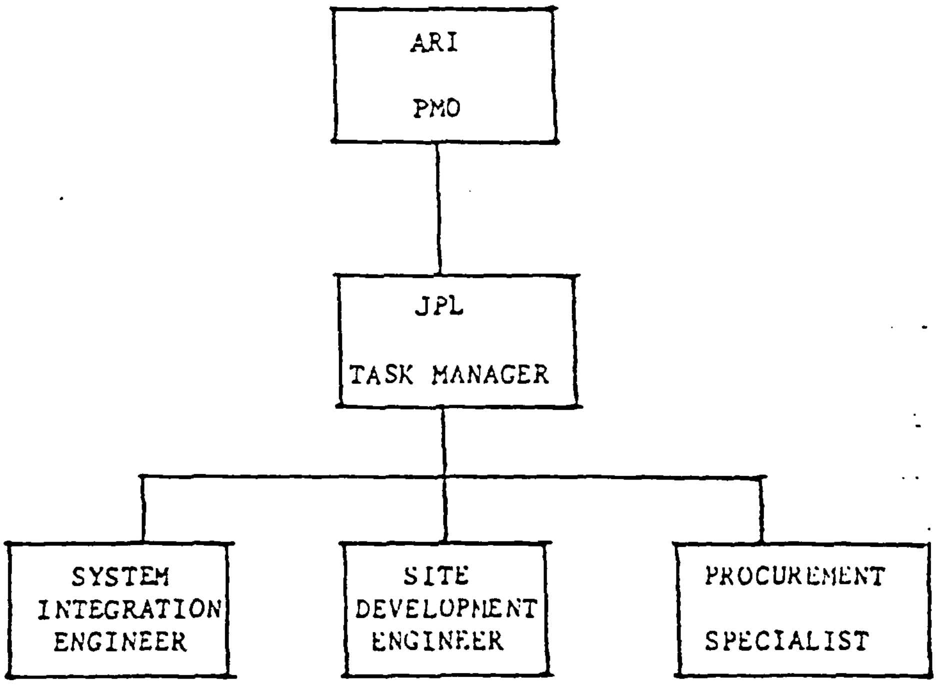
c. Hardware and Software Procurement

This work unit provides for procurement of hardware and software.

4. Phase I Organization

The following organization structure is proposed for Phase I this effort:

Phase I Organization Chart



II. BUSINESS/COST

A. Scope of Work

1. The Jet Propulsion Laboratory (JPL) will implement, for ARI, Phase I of the Training Research and Development System. In the performance of this effort JPL will, on a best efforts basis:
   a. Prepare monthly technical progress and financial status reports.
   b. Develop a Phase I Implementation Plan which includes schedules, procurement plans, and site modification plans.
   c. Procure the Phase I system as specified in the Phase I Implementation Plan.
   d. Review documentation supplied by ARI consisting of ARI plans for research and development activities related to the NTC, NTC operations, and Army training and training development processes. Based on this review, formulate a Task Plan for Phases II and III.

B. Delivery Schedule

1. JPL will deliver to ARI:
   a. Five (5) copies of a monthly, letter type, technical progress and financial status report on or before the twentieth (20) day of each month covering the preceding month.
   b. Five (5) copies of the Phase I Implementation Plan, one (1) month after start of work.
   c. The Phase I computer system on a schedule to be specified in the Phase I Implementation Plan.
   d. Five (5) copies of the Task Plan for Phases II and III, six (6) months after start of work.

2. ARI will provide JPL:

   a. A physical facility for system installation at ARI Field Unit at the Presidio of Monterey at the start of work.

   b. Background material to familiarize JPL with ARI training research and development, NTC operations and Army training and training development processes within thirty (30) days after start of work.

   c. The ARI Site Modification Plan within one (1) week after start of work.

   d. Approval of the Phase I Implementation Plan within ten (10) calendar days after receipt thereof.

<u>NOTE:</u> JPL's performance is contingent upon ARI's providing JPL the items noted in Part II, Section B2, paragraphs a. through d. as noted therein.

C. <u>Period of Performance</u>

The period of performance will be for six (6) months from the date of execution of a Task Order between the National Aeronautics and Space Administration and the California Institute of Technology.

D. <u>Proposed Contractual Arrangements</u>

1. <u>General</u>

The California Institute of Technology (Caltech) is a private nonprofit educational institution chartered under the laws of the State of California. The Jet Propulsion Laboratory (JPL) is an operating division of Caltech. Under Contract NAS7-100 with the National Aeronautics and Space Administration (NASA), Caltech/JPL performs certain research and development tasks and other related activities utilizing facilities provided by the Government.

Contract NAS7-100 is a Cost Reimbursable Educational Institution type contract. All costs incurred are billed to the Government on a 100% reimbursable basis. The costs to be charged to the proposed work would be consistent with contractual provisions and established procedures for costing of the current contract between NASA and Caltech. All charges developed at the laboratory, including JPL applied burdens, are billed to the Government as a direct charge at the rates in effect at the time the work is accomplished. Government audit is performed on a continuing basis by a Department of Defense Contract Audit Agency resident team.

In accordance with current procedures between NASA and Caltech/JPL, funding of the California Institute of Technology, Jet Propulsion Laboratory for the proposed effort may be accomplished as indicated below.

2. Funding

Your requesting document (i.e., reimbursable order, MIPR, purchase order, project order, agreement, etc.) should be addressed to the NASA Contracting Officer for Contract NAS7-100 as follows:

National Aeronautics and Space Administration
NASA Resident Office--JPL
4800 Oak Grove Drive
Pasadena, California 91109

Attention: Mr. DeVon E. Biggs, Contracting Officer

Mr. Biggs may be contacted at (213) 354-6050 or FTS 792-6050.

To prevent delays in NASA's processing and acceptance of requested documents, it is essential that the following information be included in each order:

a. Identification of the agency appropriation symbol and title to be charged.

b. The individual or office to whom financial status reports and billings are to be submitted.

c. The name, title, office code, and address of the proposed technical project manager.

d. The name, title, address, and telephone number of the cognizant contracting officer for this effort.

e. A statement as to whether your organization plans to solicit or accept proposals for substantially the same effort from private industrial, commercial, or other profit making organizations.

The agreement or order may include a Statement of Work that delineates the work to be performed by JPL as long as the scope is consistent with Part II of this proposal. It is intended that JPL will perform all work in accordance with Part II, except as may be mutually modified and agreed to, and under the terms of Contract NAS7-100. The agreement or order should also reference JPL's proposal number and date.

3. JPL Authorization

The above described contractual arrangement will permit the addition of a task order to Contract NAS7-100 for existing programs/projects at JPL specifying the work to be performed for the Army Research Institute (ARI).

4. Technical Direction

Responsibility and authority in the technical direction of this effort is that of ARI.

E. Accountability of Deliverable Property

As all work performed by JPL under any order or agreement entered into as a result of this Proposal is subject to the provisions of Contract NAS7-100 between the National Aeronautics and Space Administration (NASA) and the California Institute of Technology (Caltech), accountability of all deliverable property under such order or agreement must remain with NASA until final payment is made. On receipt of final payment and on request from the Army Research Institute (ARI), NASA will effect transfer of accountability of all such property to ARI.

F. Phase I Cost Estimate

1. Workyears (WY)

Engineering	0.87 WY
Other	-0- WY
Total	0.87 WY

2.	Total Direct Compensation (Includes Employee Benefits)	$ 58,750
3.	Travel	2,000
4.	JPL Services	5,000
5.	Procurements	340,000
6.	Total Direct Costs	$ 405,750
7.	JPL Overhead	83,350
8.	Total JPL Costs	$ 489,100
9.	NASA Contract Administration Charge	3,910
10.	Grand Total	$ 493,010

APPENDIX C

Training Research and Development System Task Plan

(for Phase I through Phase IV)

1 July 1982

Appendix C

ARMY RESEARCH INSTITUTE
FOR THE
BEHAVIORAL AND SOCIAL SCIENCES

TRAINING RESEARCH AND DEVELOPMENT SYSTEM

TASK PLAN
(For Phase I through Phase IV)

July 1, 1982

Prepared by:

A. G. Silliman
Task Manager

C. E. Herberger
Contracts Management Office

Prepared by:

J. N. James
Assistant Laboratory Director
for Defense Programs

C. H. Terhune
Acting Director

JET PROPULSION LABORATORY
California Institute of Technology
Pasadena, California 91109

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I. INTRODUCTION

TBD (PHASE I COMPLETED)

II. SCOPE OF WORK

The Jet Propulsion Laboratory (JPL) will implement, for ARI, the Training Research and Development Systems and will assist ARI in developing research and development techniques to enhance the use of this system.

During the period of Phase I of the proposed task, JPL on a best effort basis will:

1. Prepare monthly technical progress and financial status reports.
2. Develop a Phase I Implementation Plan which includes schedules, procurement plans, and site modification plans.
3. Procure the Phase I system as specified in the Phase I Implementation Plan.
4. Review documentation supplied by ARI consisting of ARI plans for research and development activities related to the NTC, NTC operations, and Army training and training development processes.
5. Prepare an Implementation Plan for Phase II.

In performance of Phase II of this tas, JPL, on a best effort basis will:

1. Prepare monthly technical progress and financial status reports.
2. Expand the Phase I system to simulate the NTC data processing and review functions for off-line performance measurement analysis.

3. Provide training to ARI-POM personnel in the operation of he NTC simulation.
4. Develop a generalized archiver/dearchiver process to reconstitute NTC history data base in a usable form for display and review on the Traing Research and Development System.
5. Prepare an Implementation Plan for Phase III.

In performance of Phase III of this task, JPL, on a best effort basis will:

1. Prepare monthly technical progress and financial status reports.
2. Design and develop a research data base including a historian data base reformation/translator.
3. Provide training to ARI-POM personnel in the use of the research data base.
4. Prepare an Implementation Plan for Phase IV.

In performance of Phase IV of this task, JPL, on a best effort basis will:

1. Prepare monthly technical progress and financial status reports.
2. Assist ARI with the development of research and development techniques for performance measurement systems, advance analytic and modeling methods, and unit training strategies for use on the Training and Research and Development System.

III. DELIVERY SCHEDULE

TBD

IV. PERIOD OF PERFORMANCE

The period of performance will be for three and one fourth (3 1/4) years from the date of execution of a Task Order between the National Aeronauti s an Space Administration and the California Institute of Technology.

V. PROPOSED CONTRACTUAL ARRANGEMENTS

A. General

The California Institute of Technology (Caltech) is a private nonprofit educational institution chartered under the laws of the State of California. The Jet Propulsion Laboratory (JPL) is an operating division of Caltech. Under Contract NAS7-100 with National Aeronautics and Space Administration (NASA), Caltech/JPL performs certain research and development tasks and other related activities utilizing facilities provided by the Government.

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a. Identification of the agency appropriation symbol and title to be charged.
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c. The name, title, office code, and address of the proposed technical project manager.
d. The name, title, address, and telephone number of the cognizant contracting officer for this effort.
e. A statement as to whether your organization plans to solicit or accept proposals for substantially the same effort from private industrial, commercial, or other profit making organizations.

The agreement or order may include a Statement of Work that delineates the work to be performed by JPL as long as the scope is consistent with Part II of this proposal. It is intended that JPL will perform all work in accordance with Part II, except as may be mutually modifed and agreed to, and under the terms of Contract NAS7-100. The agreement or order should also reference JPL's proposal number and date.

C. JPL Authorization

The above described contractual arrangement will permit the addition of a task order to Contract NAS7-100 for existing programs/projects at JPL specifying the work to be performed for the Army Research Institute (ARI).

D. Technical Direction

Responsibility and authority in the technical direction of this effort is that of ARI.

VI. ACCOUNTABILITY OF DELIVERABLE PROPERTY

As all work performed by JPL under any order or agreement entered into as a result of this Proposal is subject to the provisions of Contract NAS7-100 between the National Aeronautics and Space Administration (NASA) and the California Institute of Technology (Caltech), accountability of all deliverable property under such order or agreement must remain with NASA until final payment is made. On receipt of final payment and on request from the Army Research Institute (ARI), NASA will effect transfer of accountability of all such property to ARI.

VII. COST ESTIMATE

~~TBD~~

APPENDIX D

Phase I Implementation Plan

26 September 1982

Appendix D

PHASE I IMPLEMENTATION PLAN

for

ARMY RESEARCH INSTITUTE
TRAINING RESEARCH AND DEVELOPMENT SYSTEM

Prepared for
U. S. Army Research Institute
for Behavioral and Social Sciences

Through an agreement with
National Aeronautics and
Space Administration

by
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

Prepared by:

A. G. Silliman
Task Manager

Approved by:

R. L. Crabtree
Deputy Program Manager
Defense Information Systems

September 26, 1982

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I. INTRODUCTION

In June 1982 the Jet Propulsion Laboratory (JPL) proposed Phase I of the Training Research and Development System (TRADS) to the Army Research Institute for Behavorial and Social Sciences (ARI). That proposal was accepted and the task was started on August 13, 1982. In the interim period between the proposal submittal and the start of work on Phase I, a Task Plan for Phases II and III was completed.

This Phase I Implementation Plan describes the Jet Propulsion Laboratory's plans for Phase I of the TRADS. Specific objectives to be achieved during this phase and the resource requirements for accomplishing them are included. This document supplies a plan of operation within the framework of Proposal 80-1927, dated June 22, 1982.

II. APPLICABLE/REFERENCE DOCUMENTS

The following documents apply to this task:

A. Army Research Institute Training Research and Development System, JPL Proposal Number 80-1927, dated June 22, 1982.

B. Army Research Institute Training Research and Development System Phases II and III, JPL Task Plan Number 80-2007, dated August 30, 1982.

III. TASK BACKGROUND

During the past decade a growing concern developed within the United States Army over the lack of training available at the Battalion level and higher. This concern is based in part on the realization that the United States must meet the numerical superiority of the Soviet threat with a higher degree of coordination between military units than existing squad and company home-station training provides. These circumstances combined with technological advances such as engagement simulation and position determination systems led the U. S. Army to place a high priority on the development of a National Training Center (NTC).

The NTC is currently operating at Fort Irwin, California. Through the use of highly sophisticated state-of-the-art equipment, NTC provides the most realistic simulated battlefield environment available to a peacetime Army. The NTC accomplishes intra-Battalion and inter-Battalion coordination and training. Battalions are transported to this facility where they conduct critical training tasks that cannot be performed at home stations. To assist in this training, the NTC includes an instrumentation system for the collection and display of data during the training exercises. This data is used to formulate After Action Reviews and take home diagnostic packages.

While the NTC is a key element in the Army strategy for improving combat readiness, it only provides the mechanism for training. The army needs a coherent strategy for improving and monitoring the combat readiness of its combined arms forces. Advanced combat training programs suitable for the NTC must be designed. Mechanisms and procedures for integration of home-stations and NTC training and evaluation must be developed. Unit performance measurement capabilities must be improved and integrated with training systems. Feedback capabilities must be improved to support Army decisions on requirements, readiness, and policies. To fulfill these needs and to ensure that the NTC potential will be fully realized, the Army has established a program for developing new research capability and analytical tools to profit from the massive amounts of data collected during NTC operations.

This research program will be conducted by the Army Research Institute Field Unit at the Presidio of Monterey (ARI-POM), California. In order to carry out this mission, ARI requires a Training Research and Development System which permits extensive off-line analyses of data recorded during NTC training exercises. This document provides an implementation plan for Phase I of this system.

IV. TASK OBJECTIVES

A. LONG TERM OBJECTIVES

The long term objectives of this task are to:

1. Establish a research system to enable evaluation and analysis of Army unit training data from the NTC and other sources.
2. Provide long term technical support to ARI on training evaluation and research issues.

B. PHASE I OBJECTIVES

Specific objectives to be accomplished in Phase I are:

1. Procurement, installation, and checkout of the basic TRADS computer system.
2. Site development necessary to support the TRADS at the ARI-POM facility

V. TASK POLICIES AND CONSTRAINTS

The following policies, and constraints are imposed on this task:

A. The basic TRADS computer system will be procured before the system design is complete. This policy supports the requirement to establish the basic system as early as practicable in order to perform limited analysis on existing NTC data.

B. The basic TRADS computer system must be compatible with the NTC instrumentation system to maximize the use of NTC hardware designs and software, and to process NTC data tapes.

C. The selection of TRADS components will include evaluation of quality and reliability factors; however, the TRADS is constrained to use commercial grade equipment without redundancy or uninterruptable power techniques. These constraints support the intended use of the TRADS as an off-line, non-tactical system.

VI. USER REQUIREMENTS

The user requirements for Phase I are:

A. A system that provides as much capability as possible consistent with the funding available for Phase I.

B. Arrangement of the system in the manner that is convenient to use.

C. Provide power, air-conditioning, raised flooring and a layout plan to support future expansion of the TRADS.

VII. SYSTEM ARCHITECTURE

A. Figure 1 shows the architecture of the computer system which will be delivered in Phase I. This system includes a VAX 11/780 computer with a fixed disk of 516M bytes and a magnetic tape deck. A floating point accelerator, a 2M byte extended memory, a line printer, and an alphanumeric-video terminal are also included in this system. This configuration duplicates a portion of the NTC central instrumentation system. In later phases this duplication will allow use of the computer system with NTC generated software for data presentation and analysis.

VII. PHASE I WORK PLAN

A. WORK UNIT DESCRIPTIONS

The plans formulated by JPL for support of the TRADS task during Phase I are presented in this section. In general, the individual jobs are described without reference to schedule. A separate schedule is then provided to show how the jobs interrelate and when they will be performed.

The following work units have been designed to fulfill the Phase I objectives and meet the user requirements, policies and constraints. Accomplishment of these work units will also

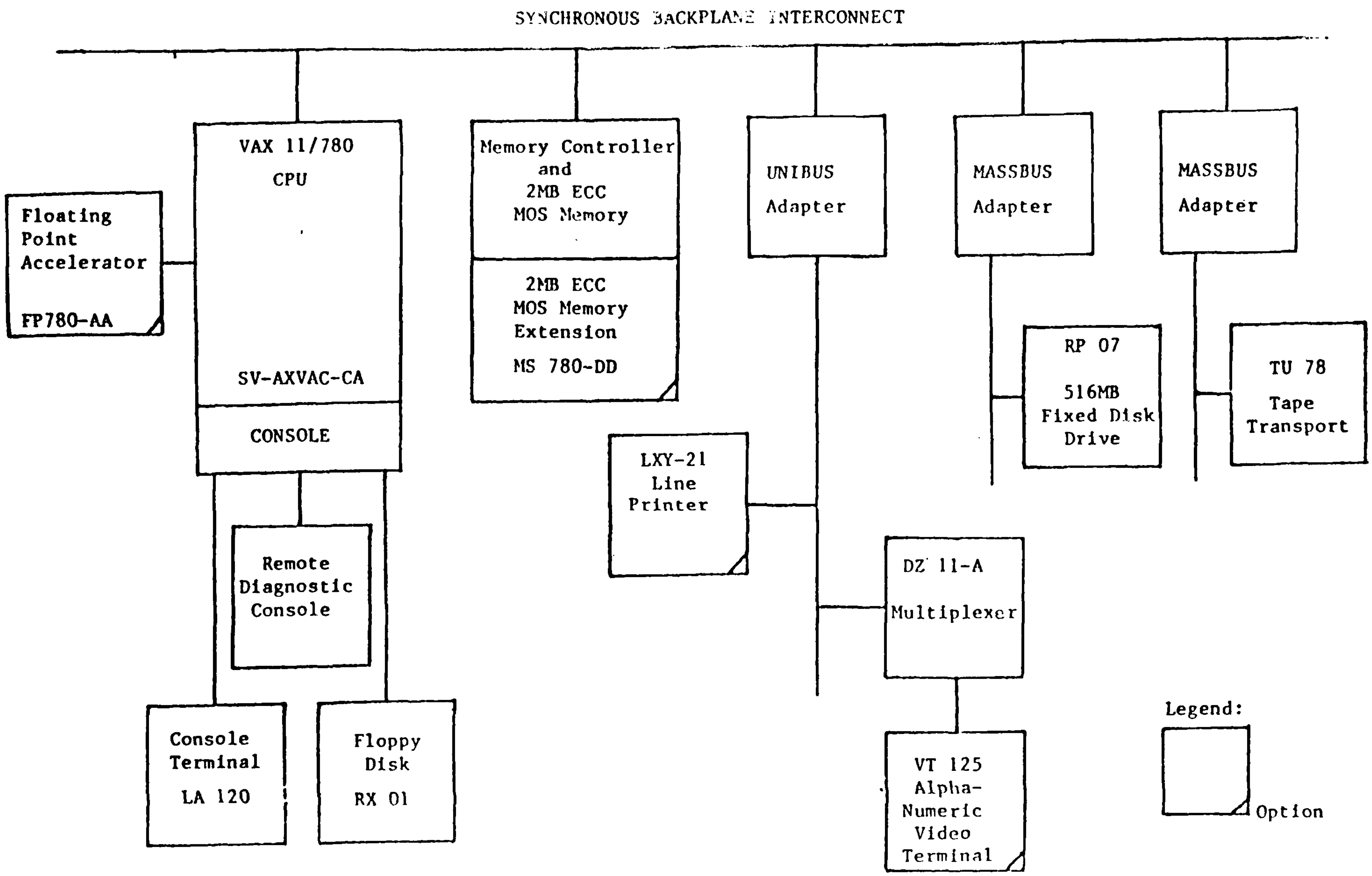


FIGURE 1. PHASE 1 SYSTEM ARCHITECTURE

achieve progress toward the long term objectives by establishment of a basic research system and establishment of a JPL team which is familiar with ARI and NTC.

1. Procurement of the Phase I TRADS Computer System

   JPL has initiated two procurement activities for the acquisition of computer hardware and software. During Phase I, these subcontract activities will involve the following:

   a. Procurement of a DEC VT125-AA Graphic Video Terminal. This terminal was procurred separately due to an immediate need by ARI, and was delivered early in this phase.

   b. Procurement of the basic computer system consisting of the following items:

Quantity	Make/Model and Description
1	DEC SVAX VCA-CA System
1	DEC QE100-AY VAX-11 FORTRAN
1	DEC FP780-AA Floating Point Accelerator
1	DEC LXY21-SY 600 LP Printer
1	DEC MS780-DD 2MB ECC Memory

   Delivery, installation and checkout of this system will be the last activity of Phase I.

2. Site Development

   The TRADS will be housed in building T-110 at the Presidio of Monterey. Four rooms within that building will be involved in site development necessary to support the TRADS system. These rooms are:

   Room 13 - Printer room
   Room 14 - Main computer room
   Room 16 - Storage room for tapes, disks and supplies
   Room 19 - Present entry to main computer room

Although the TRADS is being developed in several phases, the site development to be completed in Phase I is intended to support the final system configuration. The equipment listed in Table I is estimated to represent the final TRADS configuration for the purposes of calculating power and air-conditioning requirements, and for developing a computer system layout.

The following seven site development items must be accomplished to support the TRADS. JPL will assist ARI with these items as described below and will confirm site readiness before installation of the computer system. Other facility issues such as lighting, painting, and fire protection are the responsibility of ARI.

a. Computer System Layout Figure 2 shows the TRADS layout for the computer, the power distribution unit for the computer, air-conditioning, and storage. The NTC controller stations and terminals for the research psychologists to be added in later phases are not shown. Other areas within Building T-110, to be developed by ARI will be used for those stations and terminals.

b. Doorways The doorway changes listed below are required and are to be accomplished by ARI.

   i. Either the door between Rooms 14 and 19 or the outside door to Room 19 must be made exit only to minimize dust that could enter from the outside.

   ii. A new doorway (but no door) is to be installed between Rooms 14 and 16 as indicated in Figure 1. This will provide easy access to storage in Room 16. The old door to Room 16 should be permanently closed off.

   iii. Currently, there is a doorway (but no door) between Rooms 13 and 14. A door should be installed to improve the computer room cleanliness.

TABLE 1. ESTIMATED EQUIPMENT LIST

ITEM	AC WATTS	BTU/HR
DEC VAX 11/780 SV-AXVCA-CA 120/208V 60 Hz	10,800	43,800
FP-780	300	1,025
LXY21 (2)	900	3,078
MS 780	630	2,148
RH 780	150	512
TU 78	1,500	5,120
RM05 (4)	5,840	19,912
H9602	2,000	6,824
RP07	2,051	7,000
U OPS CAB	2,448	8,352
PDS		2,040
TOTAL	26,619	99,811

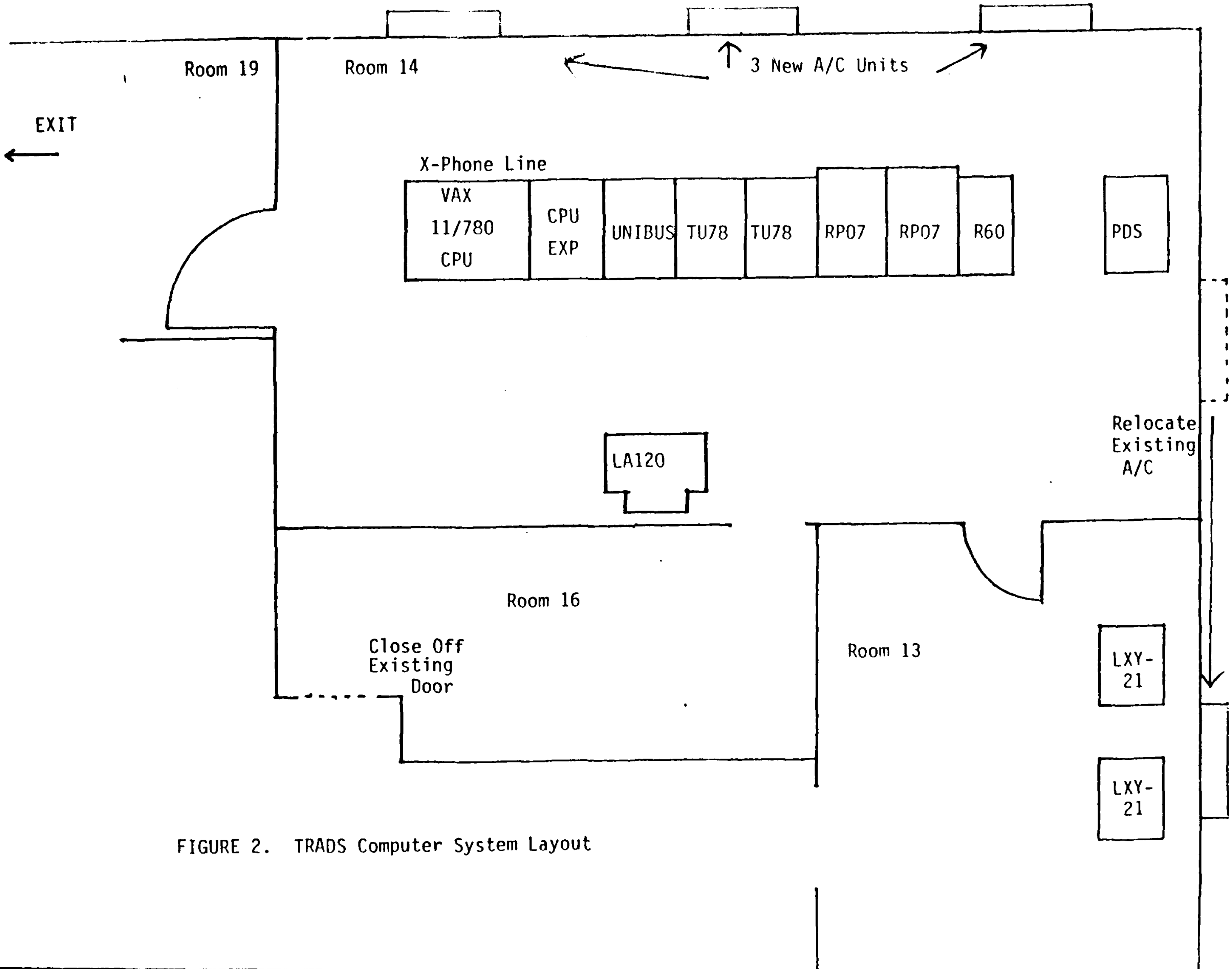


FIGURE 2. TRADS Computer System Layout

c. Computer Flooring The JPL Facility Engineering Section will develop a detailed drawing of the raised flooring for Room 14. The flooring will include seismic bracing which requires attachment to the existing concrete floor. The Facility Section will also prepare procurement specifications and subcontract the installation of this flooring.

d. Air-Conditioning Three wall-hung air-conditioning units of 3 1/2 ton capacity each will be required for Room 14. JPL will procure the units and the diffuser grills and will fabricate the transition adapters. JPL will also furnish air-conditioning layout plans to ARI. ARI will install these units and will move the window air-conditioner located in Room 14 to Room 13.

e. Electrical Requirements JPL has sized electrical requirements for the two items addressed below:

   i. Each of the three new air-conditioners require 18.9 amps at 230/208 volts. JPL will provide circuit breaker and service disconnect sizing recommendations to ARI. Service for these units is to be installed by ARI.

   ii. The computer power will be distributed through a computer power distribution unit that will be procurred by JPL. This unit will provide power to all the computer equipment to be located in Rooms 13 and 14. In addition to power distribution, this unit will provide filtering, isolation, monitoring, and emergency shut-off for various fault conditions. ARI will provide a three phase, 100 amp, 208 volt electrical service to this unit and will also connect the service to the J-Box supplied with the power distribution unit.

f. Phone Line Digital Equipment Corporation's (DEC's) Remote Diagnosis is an integral part of the VAX standard diagnostic coverage. This Remote Diagnosis provides diagnostic service by a remote DEC Service Center, using a phone line connected to the VAX computer. To use this diagnostic feature, ARI must provide a direct-dial phone line with an RJ11-C voice-grade jack at the location indicated in Figure 2.

3. Integration and Test

The schedule in Section VII.E indicates a plan to have all the site development work completed by the time the VAX computer system is delivered. The delivery company will move the crated equipment into the computer room. DEC installation personnel will then uncrate the equipment, set it up and perform system checkout. JPL will ensure the setup and checkout is performed but will not conduct any JPL acceptance testing.

Should the equipment be delivered before the site development is complete, ARI must provide a temporary storage area. Once the site work has been completed, ARI will have to move the crated equipment into the computer room. Then JPL will schedule DEC service to perform setup and checkout. JPL and ARI must mutually integrate the site development work and the system setup and checkout.

4. Preparation for Follow-On Activity

A Task Plan for Phases II and III has been completed. This Plan includes the objectives and scope of work for Phases II and III. However, the system functional requirements and the system functional design for the complete TRADS must be developed before Implementation Plans can be written for these follow-on phases. In preparation for the follow-on phases, JPL will study both the functional requirements and the functional design during Phase I. This study will include discussing the requirements with ARI and reviewing documentation supplied by ARI consisting of ARI plans for research and development activities related to the NTC, NTC operations, and Army training and training development processes.

B. ORGANIZATION AND RESPONSIBILITIES

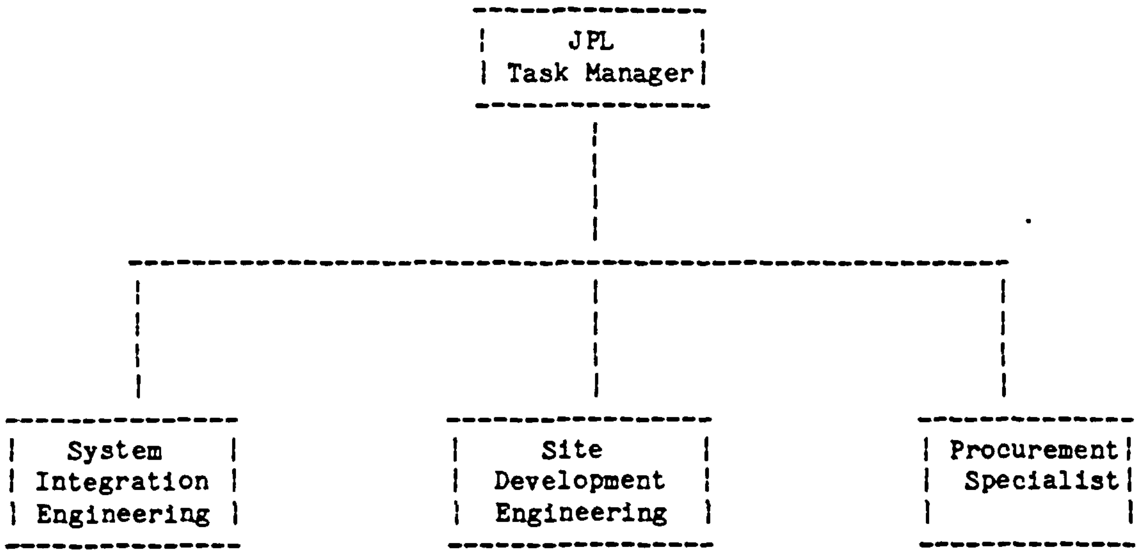
1. Organization

The TRADS is organized as a task within the Defense Information Systems Program Office. The task organization is shown in Figure 3. Technical expertise residing within the Defense Program Office and the Technical Divisions, under direct control of the Task Manager, will be utilized to perform the system integration. Site development engineering will be performed by the JPL Facility Engineering Section through the use of Facility Service Requests. The JPL Procurement Division will conduct the necessary procurements using standard JPL procurement policies. Procurement personnel will work with the Task Manager and other TRADS personnel as required for each procurement.

2. Technical Control and Direction

Control and direction within JPL will be exercised by the JPL Task Manager. JPL meetings are held approximately weekly with each engineer reporting the status of TRADS activities in his area. These meetings are supplemented with _ad hoc_ conferences and communications when needed to ensure coordination and control. An additional means of control is the preparation of the monthly technical progress and financial status and other reports, plans, and presentations designed to provide schedule and resource status, problem identification, approaches to problem solutions, and technical results to JPL and ARI management.

Figure 3. Task Organization



3. Financial Control

The TRADS Task Manager will be responsible for financial control of this task. Control will be exercised by approval of all procurement requisitions, work orders, and travel requests and by reviewing direct time charges each week.

The existing JPL System for Resource Management (SRM) will be used for planning, analysis, and reporting of financial data. Comparison and analysis of monthly Resource Status Reports provided by the JPL SRM system, against these plans will be conducted so that status can be reported on a regular basis to JPL and ARI management.

C. WORK BREAKDOWN STRUCTURE

Only one SRM will be used for planning and control of Phase I. Adequate visibility will be available by the use of the following line entries on the SRM:

1. JPL Workforce - Task Management and System Integration (a maximum of three people) will be charged to this line entry. System Integration will include the preliminary system design, preparation of Automatic Data Processing Equipment plans and specifications necessary for equipment procurement, preparation of the Phase I Implementation Plan, preparation of the Phase II Implementation Plan and coordination of facility and procurement issues.

2. Travel - All travel costs will be accumulated on this line entry.

3. Service - Reproduction and documentation costs will be accumulated on this line entry.

4. System Procurement - Basic computer system hardware and software procurement costs will be accumulated on this line entry.

5. Facilities - Facility engineering costs and facility procurement costs for air-conditioning, flooring, and the power distribution unit will be accumulated on this line entry.

D. INTERFACE DESCRIPTION

Meetings will be held with ARI as required to define requirements and discuss status plans and problems. These meetings will be arranged by the JPL Task Manager with support and participation by TRADS personnel as needed. These meetings will be supplemented with ad hoc conferences and communications when needed to ensure coordination and control. JPL may also initiate conferences with NTC subcontractors for the purposes of obtaining information on the NTC design and performance.

E. SCHEDULE

The Phase I schedule is shown in Figure 4. Phase I will end at the completion of delivery and check out of the computer system.

IX. DOCUMENTATION

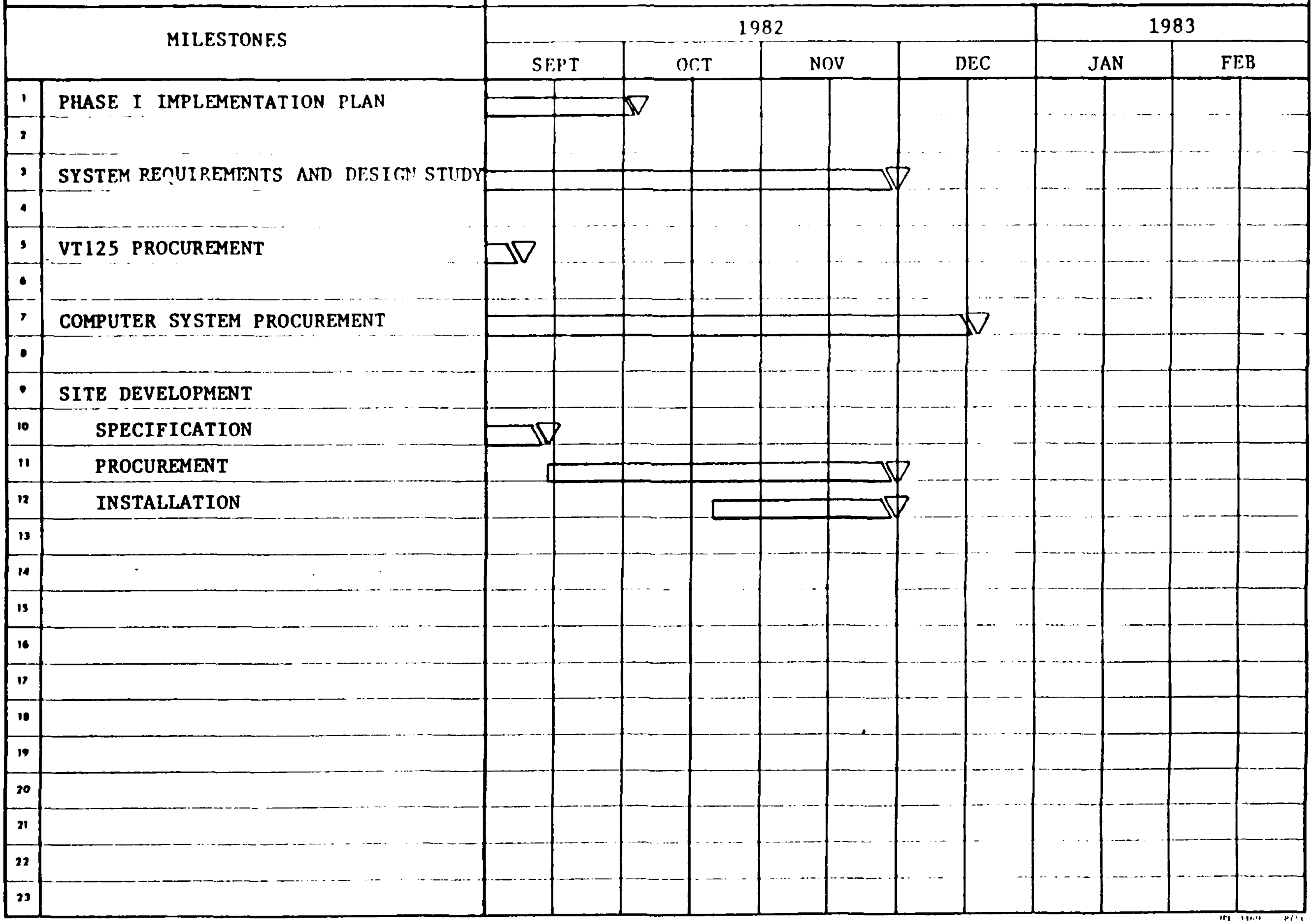
Phase I documentation will consist of monthly technical progress and financial status reports to ARI, this Phase I Implementation Plan, and site development drawings. No formal documentation plan is required for this task.

X. PROCUREMENT

Subcontracts will be awarded by JPL in accordance with established JPL procurement policies and procedures. A contract Technical Manager and a Contract Negotiator will be assigned by JPL for each subcontract to prepare the procurement package and to provide the required contract management.

A Request for Proposal (RFP) or Request for Quotation (RFQ) will be issued by JPL only after thorough review and approval by JPL management. Preparation of the RFP or RFQ will ordinarily include establishment of a

FIGURE 4. PHASE I TRADS SCHEDULE



source list, preparation of evaluation criteria, preparation of a statement of work, listing of applicable requirements, and preparation of the RFP or RFQ instructions.

JPL will work with vendors to assure that they remain on schedule and meet all performance specifications. Only established vendors and proven commercially available products shall be selected, except where NTC compatibility demands otherwise. Vendor progress will be reported in the monthly progress reports to ARI.

JPL will monitor the installation and checkout of all equipment by vendors, conduct or monitor all required equipment acceptance tests, and assure that any equipment deficiencies are corrected by the vendor.

XI. QUALITY ASSURANCE, SAFETY, AND RELIABILITY

A. QUALITY ASSURANCE

Since Phase I involves a low quantity of commercial items, a quality assurance plan is not required. Task engineers will be responsible for verification of delivery, condition of delivery, and proper installation and checkout.

B. SAFETY

A safety plan is not required for this task. The facility designs prepared by JPL will provide both personnel and equipment safety. The safety codes normally used at JPL will be followed since the Presidio of Monterey is not under jurisdication of the Monterey Building and Safety Department. All electrical equipment to be delivered will be U. L. listed. A commercial computer power distribution unit will supply power to all the computer hardware, thus preventing overloaded circuits.

C. RELIABILITY

A reliability plan is not required for this task. The policies and constraints stated in Paragraph V.C will be followed. This includes the evaluation of reliability in the selection of all TRADS components.

XII. REPORTS AND REVIEWS

Monthly technical progress and financial status reports will be submitted to ARI in JPL letter type format. No formal reviews are planned for Phase I. Informal reviews within JPL will be conducted. These will consist of discussions on task-related matters between the Task Manager and individuals performing the work and between the Task Manager and both line and program management. These informal reviews will provide assurance that quality and consistency with JPL objectives are being met.

XIII. PROPERTY ACCOUNTABILITY

JPL's property accounting system is in accordance with the NASA Financial Management Manual and Appendix B to the NASA Procurement Regulation as approved by NASA. Uniquely identifiable property numbers will be assigned to all accountable equipment (both purchased and GFE), a responsible individual will be identified for each item, and the equipment will be inventoried annually. A list of purchased and GFE accountable equipment will be reported to ARI in the monthly technical progress and financial status reports.

As all work performed by JPL under any order or agreement entered into in the conduct of this task is subject to the provisions of Contract NAS7-918 between the National Aeronautics and Space Administration (NASA) and the California Institute of Technology, accountability of all deliverable property under such order or agreement must remain with NASA until final payment is made. On receipt of final payment and on request from NASA will effect transfer of accountability of all such property to ARI.

XIV. RESOURCE PLANS

Figure 5 shows the planned obligation and manpower for Phase I.

The workforce reduction at the end of November indicates the completion of all Phase I activities except installation and checkout of the computer system. The installation and checkout that is scheduled for completion in December will terminate Phase I. Contingency funding is planned for 1/2 man through January to cover unexpected late deliveries.

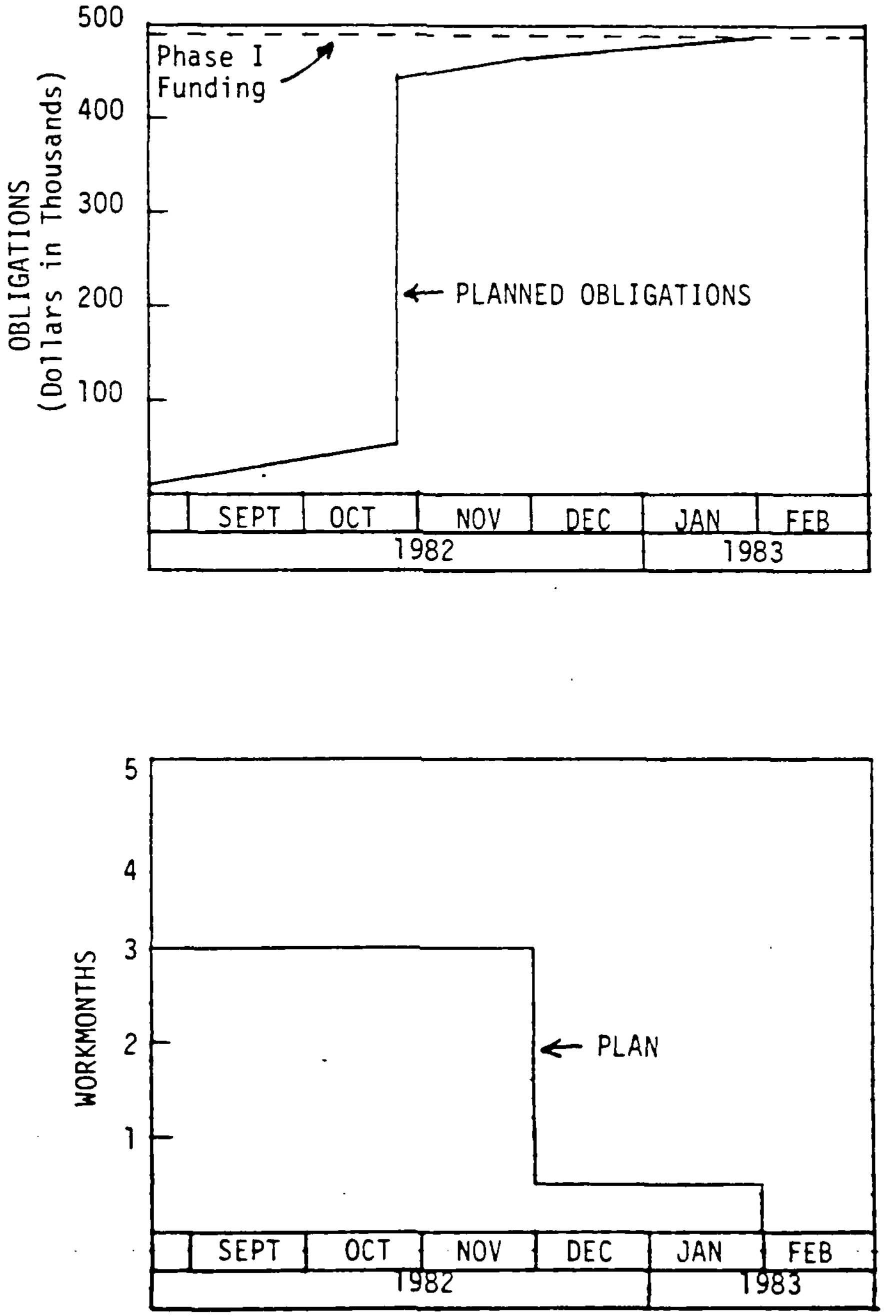


FIGURE 5. RESOURCE PLANS

APPENDICES

A. ABBREVIATIONS AND ACRONYMS

ARI	Army Research Institute
DEC	Digital Equipment Corporation
JPL	Jet Propulsion Laboratory
NASA	National Aeronautics and Space Administration
NTC	National Training Center
POM	Presidio of Monterey
RFP	Request for Proposal
RFQ	Request for Quotation
SRM	System for Resource Management
TRADS	Training Research and Development System

APPENDIX E

ADP Equipment Acquisition Plan

25 August 1982

Appendix E

JET PROPULSION LABORATORY
California Institute of Technology
4800 Oak Grove Dr., Pasadena, CA 91109

ADP EQUIPMENT ACQUISITION PLAN

AP- 453

August 25, 1982

(Date)

Army Research Institute
Training Research and Development System

(Descriptive Title)

A. C. Silliman

(Prepared By)

ABSTRACT

The Jet Propulsion Laboratory is supporting the Army Research Institute for the Behavioral and Social Sciences in the development of a research capability which will be used to study Army unit training. This ADPE Acquisition Plan which covers Phase I of the task, is for the procurement of the computer and associated ADPE equipment for this research capability.

The Army Research Institute will utilize data obtained at the National Training Center located at Fort Irwin, California. In order to study this data, the Army Research Institute must install the identical control center configuration as exists at the National Training Center, to simulate operations, utilize already developed programs and to write new programs for their use. Thus, this plan specifies the acquisition of a Digital Equipment Corporation VAX-11/780 system and peripheral devices. The system cost is estimated to be $343,800 and will be procured competitively. The system life is expected to be over eight (8) years, since the National Training Center upgrade is not expected until the 1990's.

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I. INTRODUCTION

The National Training Center (NTC) at Fort Irwin, California, provides the most realistic training available to a modern peacetime army. Consequently, the NTC has the potential for greatly improving the training of maneuver arms battalions, thereby enhancing the training component of combat readiness. For this potential to be fully realized, there is a critical need to develop new research capability and analytical tools to profit from the massive amounts of data collected during NTC operations. This capability is necessary to support both the current NTC Phase I operations and refinements as well as the future design of the NTC Phase II system. Key areas in need of improvement include performance measurement and diagnosis, training information display and feedback, and tactical operations analysis. Further, unit training must be considered as a total integrated system; NTC and home-station training practices must both be considered when designing systems for improving the proficiency of tactical units. Finally, NTC-generated data will be important for research on issues beyond unit training and training management. The new research capability must be able to support diverse Army R&D priorities ranging from problems in manned-systems integration to problems in personnel acquisition, assignment, and retention.

This research will be performed by the Army Research Institute Field Unit at the Presidio of Monterey (ARI-POM), California. This Field Unit has the mission within ARI of conducting research on unit training and performance measurement. In order to carry out this mission, ARI requires a Training Research and Development System which is fully compatible with that developed for the NTC and which can expand to permit extensive off-line analyses of data recorded during NTC training exercises.

This system will be installed at ARI-POM California. Site preparation support will be given to ARI. JPL will be responsible for the implementation of the system, which includes the installation of the equipment, installation of the software, integration of any upgrade and maintenance of the system during the 2 1/2 years of the task. Thereafter, the system will be transferred to ARI.

In subsequent phases of the task, JPL will develop the capability for ARI to organize and use the vast amount of data that is acquired at NTC. A comprehensive data base management system will be developed to allow for efficient usage of the simulated battlefield acquired data. Additionally, investigations will be made into the use of three dimensional computer graphics to improve NTC displays. Other data base utilization, such as line-of-sight algorithms for Fort Irwin, California will also be investigated. JPL, with its background in data base systems and computer graphics, is well suited to provide ARI with the required research support.

II. FUNCTIONAL REQUIREMENTS

JPL will support the implementation of the ARI Training Research and Development System as well as developing of tools to utilize the NTC data.

The procurement of the computer system for the Training Research and Development System which will be installed at ARI-POM is the principal component of the initial phase of the task to spport ARI. This system must be compatible with the existing DEC VAX 11/780 computer system at NTC to take advantage of the software developed for NTC use, and to enable the creation of new software that can be used by NTC.

The equipment list presented in this plan is the Phase I procurement items. A study will be performed during this Phase I to determine the exact additional equipment to fulfill the ARI mission needs.

Special NTC equipment as well as expanded system needs for research will be examined. The additional equipment if required will be procured during Phase II of this task. A new ADPE acquisition plan or a revision to this plan will be developed depending upon the outcome of the study.

III. ALTERNATIVES CONSIDERED

Because of the requirement that the system be an exact copy of the NTC VAX system, the use of a VAX based computer system is a necessity. Because of the requirement that the system be installed at ARI-POM, California this precludes the use of any system at JPL.

An examination of GSA, NASA and JPL surplus ADPE lists indicates that there is no available ADPE equipment that meets the requirements of this plan.

IV. PROPOSED SYSTEM

The required ADPE system must duplicate a subset of the existing NTC computer configuration. The NTC system has multiple Digital Equipment Corporation VAX 11/780 computer systems. The required Training Research and Development System configuration is shown in Appendix B and the ADPE components are listed in Section VI.

V. JUSTIFICATION

JPL has undertaken the task to assist ARI in the development of training research and development mission. JPL is required to provide and implement the baseline computer system in the exact configuration as currently is used in NTC. In order to accomplish this implementation, JPL must procure the computing equipment listed in this Plan.

VI. ADP EQUIPMENT LIST

Item #	Qty	Item Model #	Functional Description	Purchase Price	Monthly Lease Rate	Monthl Maint Rate
1.	1 ea	DEC SV-AXVCA-CA	VAX-11/780 CPU 2MB ECC MOS Memory 516 MB Fixed Disk Drive with MBA 6250/1600 b/in Tape T.ansport with MBA 8 line Asynchronous Multiplexer Console Terminal VAX/VMS Operating System	$300,000	$ 12,000	$ 1,1
2.	1 ea	DEC FP 780-AA	High-performance Floating Point Accelerator	$ 11,200	$ 448	$
3.	1 ea	DEC LXY21-5Y	132-column, 96-character dot matrix printer and plotter with control unit	15,800	1,264	1
4.	1 ea	DEC MS780-DD	2 MB ECC MOS expansion memory	13,000		2
5.	1 ea	DEC VT125-AA	Extended Alphanumeric Video Terminal with Data Plotting Extensions. Bit Map Graphics, Automatic vector and curve generation	3,800	152	
		Total		$343,800	$ 13,864	$ 1,

VII. UTILIZATION

The anticipated period of use of this equipment is until 1990 after which an upgrade is possible in support of the next generation NTC. Utilization is expected to be about 8 hours per day, 5 days per week. The work load is expected to be divided among various efforts in programming and operational analysis.

Projected Workload:

Science and Engineering:	50%
Data Reduction:	25%
Simulation:	25%

VIII. LEASE vs PURCHASE ANALYSIS

N = 96 months

Purchase Cost = P + M + I

P = Basic Purchase Price	=	$343,800
M = Maintenance Costs (96 months) x ($ 1,363)	=	130,848
I = Interest Costs (14%) x ($343,800) x (96+12)/24	=	216,594
Total Cost to Purchase	=	$691,242

Lease Cost = L + M + T

L = Basic Lease Cost (96 months) x ($ 13,864)	=	$1,339,944
M = Maintenance not included in L (96 months) x ($ 1,363)	=	130,848
T = California Use Tax *		----------
Total Cost to Lease	=	$1,461,792

* Lease cost used for GSA schedule and does not include state use tax

This analysis indicates that the least cost option is to procure the specified system.

IX. PROCUREMENT METHOD

This system is proposed to be procured as a competitive procurement. The procurement, however, must provide to ARI the exact configuration as currently utilized by NTC. The sole source specification justification for the Digital Equipment Corporation VAX 11/780 computer system is attached to this plan as Appendix D.

This procurement will provide the initial Training Research and Development System. Procurement method for any future equipment requirement will be determined at that time.

X. FUNDING SUMMARY

The funding will be wholly from Account Code #735-60203-0--8300.

JPL will procure the system in FY82, install it in FY83, maintain the system through the first half FY85 and transfer all activities to ARI at the conclusion of the task on April 1, 1985.

	FY82	FY83	FY84	FY85
Acquisition Costs				
Purchase	$343,800	$ -0-	$ -0-	$ -0-
Burden Cost	53,633			
Total Acquisition Cost	$397,433	$ -0-	$ -0-	$ -0-

	FY82	FY83	FY84	FY85
Operational Costs				
Maintenance	$ -0-	$ 13,360	$ 16,356	$ 6,815
Installation*	-0-	-0-	-0-	-0-
Site Preparation Equipment	90,000	-0-	-0-	-0-
Burden Cost	14,040	2,126	2,552	1,063
Total Operational Cost	$104,040	$ 15,756	$ 18,908	$ 7,878
Total Planned Cost	$501,473	$ 15,756	$ 18,908	$ 7,878

* Included in the purchase price.

XI. ASCII COMPATIBLE

This system is to be fully ASCII compatible. No exemption is requested.

XII. IMPLEMENTATION SCHEDULE

Acquisition Plan approved	14 Sept.,1982
Purchase Order issued	18 Oct., 1982
Facility Preparation completed	17 Dec., 1982
Equipment Delivered	17 Dec., 1982
Equipment Operational	7 Jan., 1983
Equipment Transfer to ARI	1 Apr., 1985

XIII. JPL AUTOMATIC DATA PROCESSING PLAN REFERENCE

The proposed acquisition does not appear in the JPL 1984 ADP Plan, dated 14/Aug/1982, but will appear in all future issues as part of NASA/GSA FMC 74-2 System NC-55-07-TR, JPL ADPAR Index 07-67.

XIV. FACILITY DESCRIPTION

The VAX-11/780 will be installed at a facility at ARI-POM, California.

Facility preparation will include; power conditioning, power distribution, environmental conditioning and computer flooring. ARI has designated the building and rooms that will be modified to support the system.

The estimated facility preparation cost is $90K which includes the cost for power conditioning, power distribution, environmental conditioning and flooring.

XV. SECURITY PROVISION

The facility is located at the Presidio of Monterey, in Monterey, Caifornia a U. S. Army facility. Access to the facility is controlled. The facility contains an inner office that will be used for software media storage. Also, JPL will house at JPL Pasadena, a duplicate set of all software provided by JPL during the duration of this task for backup purpose.

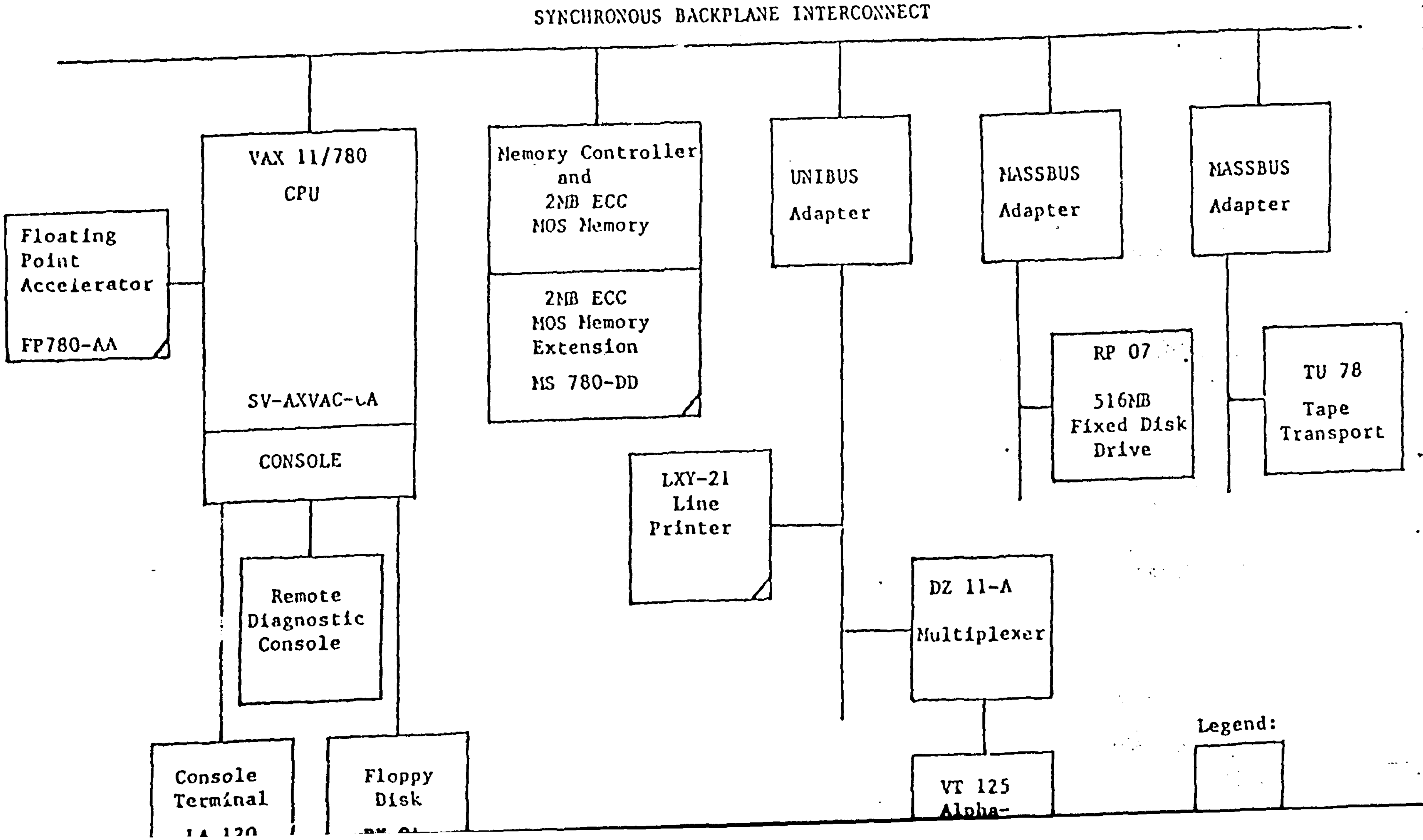
XVI. APPENDIX

A. Glossary of terms

ADPE	Automatic Data Processing Equipment
ASCII	American Standard Code for Information Interchange
ARI	Army Research Institute
b/in.	bits per inch
DEC	Digital Equipment Corp.
JPL	Jet Propulsion Laboratory
MB	Mega Byte
NTC	National Training Center, Fort Irwin, CA
POM	Presidio of Monterey

ARMY RESEARCH INSTITUTE (ARI) TRAINING RESEARCH AND DEVELOPMENT SYSTEM

PHASE I BLOCK DIAGRAM



APPENDIX F

Training Research and Development System

Phases II and III

30 August 1982

Appendix F

ARMY RESEARCH INSTITUTE

TRAINING RESEARCH AND DEVELOPMENT SYSTEM

PHASES II AND III

to

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

JPL Task Plan No. 80-2007

August 30, 1982

Prepared by:

A. G. Silliman
Task Manager

Prepared by:

C. E. Herberger
Contracts Administrator
Specialist

Approved for the Jet
Propulsion Laboratory:

C. H. Terhune, Jr.
Acting Director

Approved for the California
Institute of Technology:

Donald R. Fowler
General Counsel

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California 91109

TABLE OF CONTENTS

I. INTRODUCTION

A. Background

The National Training Center (NTC) at Fort Irwin, California, is developing an integrated system for training and evaluation of combined arms battalions. This system provides a highly realistic simulated battlefield environment, supported by a state-of-the-art instrumentation system. The scale, complexity, and realism of the exercises planned for the NTC have never before been conducted. To ensure that the NTC potential will be fully realized, the Army has established a program for developing new research capability and analytical tools to profit from the massive amounts of data collected during NTC operations. Key areas to be researched include performance measurement and diagnosis, training information display and feedback, and tactical operations analysis.

This research will be performed by the Army Research Institute Field Unit at the Presidio of Monterey (ARI-POM), California. In order to carry out this mission, ARI requires a Training Research and Development System which is fully compatible with the NTC instrumentation system and which permits extensive off-line analyses of data recorded during NTC training exercises.

B. Objective

The Jet Propulsion Laboratory (JPL) submitted Proposal number 80-1927, dated June 22, 1982, to ARI for implementation of the Training Research and Development System. That Proposal outlined a three phased approach but addressed only the Phase I effort and cost. ARI has accepted that Proposal and funding has been received for a Phase I start of August 13, 1982. The objective of this Task Plan is to assist ARI in long term planning by proposing efforts to be conducted in Phases II and III and providing cost estimates for these phases.

II. BUSINESS AND COST

A. SCOPE OF WORK

The Jet Propulsion Laboratory (JPL) will implement, for ARI, Phases II and III of the Training Research and Development System and will assist ARI in developing research and development techniques to enhance the use of this system. In performance of this task JPL will, on a best effort basis:

1. Phase II

   a. Prepare monthly technical progress and financial status reports, and conduct quarterly status meetings.

   b. Expand the Phase I system to retrieve data from the primary NTC data tapes and to display the data in the NTC format. This expansion will be based on the 500 player NTC system.

   c. Develop user requirements for conducting behavioral and social science research on the NTC data using the Training Research and Development System.

   d. Provide system maintenance of the Training Research and Development System.

   e. Prepare a System Implementation Plan for Phase II.

   f. Prepare a System Implementation Plan for Phase III.

2. Phase III

   a. Prepare monthly technical progress and financial status reports, and conduct quarterly status meetings.

   b. Design and implement a research data base management system for conducting research on the NTC data.

   c. Provide training to ARI-POM personnel in the use of the research data base management system.

   d. Assist ARI with the development of research and development techniques for performance measurement systems, advance analytic and modeling methods, and unit training strategies for use on the Training and Research and Development System.

e. Provide system maintenance of the Training Research and Development System.

f. Investigate the use of three dimensional computer-graphics rendering techniques to improve NTC displays for real time and home station use.

g. Investigate line-of-sight algorithms for the Fort Irwin terrain.

B. DELIVERY SCHEDULE

1. JPL will deliver to ARI in JPL format:

a. Five copies of a monthly, letter type, technical progress and financial status report on or before the twentieth day of each month covering the preceding month.

b. Five copies of the Phase II System Implementation Plan one month after the start of work.

c. The following will be delivered as specified in the Phase II System Implementation Plan:

i. Phase II system expansion

ii. Five copies of the Users Requirements Document

d. Five copies of the Phase III System Implementation Plan, twelve months after the start of work.

e. The following will be delivered as specified in the Phase III System Implementation Plan:

i. A research data base management system

ii. Five copies of a Feasibility Report on the Use of Three Dimensional Rendering

iii. Five copies of a Line-of-Sight Algorithms Report

iv. Training to ARI-POM personnel in the use of the research data base management system

2. ARI will provide JPL approval of the System Implementation Plans within ten (10) calendar days after receipt thereof.

C. PERIOD OF PERFORMANCE

The period of performance will be for two years from the date of execution of a Task Order between the National Aeronautics and Space Administration and the California Institute of Technology.

D. PROPOSED CONTRACTUAL ARRANGEMENTS

1. General

The California Institute of Technology (Caltech) is a private nonprofit educational institution chartered under the laws of the State of California. The Jet Propulsion Laboratory (JPL) is an operating division of Caltech. Under Contract NAS7-100 with National Aeronautics and Space Administration (NASA), Caltech/JPL performs certain research and development tasks and other related activities utilizing facilities provided by the Government.

Contract NAS7-100 is a Cost Reimbursable Educational Institution type contract. All costs incurred are billed to the Government on a 100% reimbursable basis. The costs to be charged to the proposed work would be consistent with contractual provisions and established procedures for costing of the current contract between NASA and Caltech. All charges developed at the Laboratory, including JPL applied burdens, are billed to the Government as a direct charge at the rates in effect at the time the work is accomplished. Government audit is performed on a continuing basis by a Department of Defense Contract Audit Agency resident team.

In accordance with current procedures between NASA and Caltech/JPL, funding of the California Institute of Technology, Jet Propulsion Laboratory for the proposed effort may be accomplished as indicated below.

2. <u>Funding</u>

Your requesting document (i.e., reimbursable order, MIPR, purchase order, project order, agreement, etc.) should be addressed to the NASA Contrating Officer for Contract NAS7-100 as follows:

> National Aeronautics and Space Administration
> NASA Resident Office -- JPL
> 4800 Oak Grove Drive
> Pasadena, California 91109
>
> Attention: Mr. DeVon E. Biggs, Contracting Officer

Mr. Biggs may be contacted at (213) 354-6050 or FTS 792-6050.

To prevent delays in NASA's processing and acceptance of requested documents, it is essential that the following information be included in each order:

a. Identification of the agency appropriation symbol and title to be charged.

b. The individual or office to whom financial status reports and billings are to be submitted.

c. The name, title, office code, and address of the proposed technical project manager.

d. The name, title, address, and telephone number of the cognizant contracting officer for this effort.

e. A statement as to whether your organization plans to solicit or accept proposals for substantially the same effort from private industrial, commercial, or other profit making organizations.

The agreement or order may include a Statement of Work that delineates the work to be performed by JPL as long as the scope is consistent with Part II of this proposal. It is intended that JPL will perform all work in accordance with Part II, except as may be mutually modifed and agreed to, and under the terms of Contract NAS7-100. The agreement or order should also reference JPL's proposal number and date.

3. JPL Authorization

The above described contractual arrangement will permit the addition of a task order to Contract NAS7-100 for existing programs/projects at JPL specifying the work to be performed for the Army Research Institute (ARI).

4. Technical Direction

Technical direction and monitoring of technical/cost/schedule performance is the responsibility of ARI.

E. ACCOUNTABILITY OF DELIVERABLE PROPERTY

As all work performed by JPL under any order or agreement entered into as a result of this Proposal is subject to the provisions of Contract NAS7-100 between the National Aeronautics and Space Administration (NASA) and the California Institute of Technology (Caltech), accountability of all deliverable property under such order or agreement must remain with NASA until final payment is made. On receipt of final payment and on request from the Army Research Institute (ARI), NASA will effect transfer of accountability of all such property to ARI.

F. COST ESTIMATE

1. Workyears (WY)

	Phase II	Phase II
Engineering	4.0 WY	5.4 WY
Other	-0-	-0-
Total	4.0 WY	5.4 WY

		Phase II	Phase III	Total
2.	Total Direct Compensation (Includes Employee Benefits)	$ 254,000	$ 368,000	$ 622,000
3.	Travel	12,000	14,000	26,000
4.	JPL Services	12,000	14,000	26,000
5.	Procurements	728,000	56,000	784,000
6.	Total Direct Costs	$1,006,000	$ 452,000	$1,458,000
7.	JPL Overhead	244,000	196,000	440,000
8.	Total JPL Costs	$1,250,000	$ 648,000	$1,898,000
9.	NASA Contract Administration Charge	10,000	5,184	15,184
10.	Total	$1,260,000	$ 653,184	$1,913,184

APPENDIX G

Display and Control Subsystem for ARI-POM TRADS-SOW

20 May 1983

Appendix G

1-036-71-840-11
DE:PP:05:0004

DISPLAY AND CONTROL SUBSYSTEM FOR ARI-POM TRADS

VOLUME I
TECHNICAL/MANAGEMENT PROPOSAL

PROPOSAL IN RESPONSE TO
JPL RFP BP-6-9556

20 MAY 1983

SCIENCE APPLICATIONS, LA JOLLA, CALIFORNIA
ALBUQUERQUE • ANN ARBOR • ARLINGTON • ATLANTA • BOSTON • CHICAGO • HUNTSVILLE
LOS ANGELES • McLEAN • PALO ALTO • SANTA BARBARA • SUNNYVALE • TUCSON

P.O. Box 2351, 1200 Prospect Street, La Jolla, California 92037

3.0 STATEMENT OF WORK

SAI will perform all work necessary to procure, fabricate, assemble, deliver, install, and make operational the Display and Control Subsystem (DCS) for use in the Training Research and Development System (TRADS) at the Army Research Institute in Monterey, California (ARI-POM). Specifically, SAI will put forth its best effort to perform the following tasks:

Task 1.0 Project Management

Provide day-to-day management of the project, including liasons with JPL and ARI personnel, planning, staffing, and executing all work within this SOW.

Provide one-day monthly status meetings at the SAI facility in La Jolla, California. Submit to the JPL Contract Negotiator monthly letter reports summarizing the project status and the monthly meeting results.

Provide two (2) sets of NTC documentation for all hardware and software deliverable under this contract. Document all hardware and software modifications made under this contract to the NTC standards. Submit a final hardware list including the model number, description, and cost of each item delivered under this contract.

Task 2.0 Controller Station Acquisition

Replicate two (2) National Training Center (NTC) Display and Control Stations. Each station shall include the following:

1. One (1) Gould DeAnza Visacom/23 Visual Computer System with a graphics processor and a 19-inch color graphics monitor.

2. Two (2) Digital Equipment Corporation VT125 alphanumeric terminals.

3. One (1) digitizing tablet and pen.

For one of the stations, include a station console designed to fit into a corner of a room.

Provide a large screen display and interface equipment necessary to display the color graphics from one of the Display and Control Stations.

Task 3.0 Software Acquisition

Provide and make operational all necessary software components required to retrieve data from the NTC Exercise History Data tapes and to manipulate and display these data. Specifically, all required NTC Interactive Display and

Control (IDC) software developed for the 500 Player NTC Instrumentation System shall be recovered and modified as necessary to make it operational on the ARI-POM computer system.

This software will be capable of reading and causing to be displayed the following NTC data: position/location, firing event data (direct and indirect), communications keying event data, and all other data currently maintained to generate NTC alphanumeric and graphic displays. The software will also be capable of replaying all alert and free format messages entered during the course of NTC exercises. The software shall be capable of driving the two Display and Control Stations from the same or different NTC exercise History Data simultaneously.

The VAX-based software will be provided in FORTRAN 77. The LSI 11/23-based software (on the graphics processor) will be provided in FORTRAN 4 plus. All new software will be documented to NTC standards.

Task 4.0 Delivery, Installation, and Checkout

Deliver all hardware and software items provided in Tasks 2.0 and 3.0 to ARI-POM. Supply all interface equipment, cables, and miscellaneous items as required. The hardware and software will be installed on the ARI-POM computer system as follows:

1. The supplied items will interface with the VAX computer located in Building 110, Room 14 at ARI-POM. The ARI-POM computer consists of an SV-AXECA-CA VAX 11/780. This system includes 4 MB memory, 456 MB RA81 disk drive, a TEU 78 tape subsystem, and a DZ11-A multiplexer.

2. One (1) Display and Control Station will be installed in Building 110, Room 19.

3. One (1) Display and Control Station will be installed in Building 110, Room 20.

4. The large screen display will be installed in Building 110, Room 20.

Task 5.0 Acceptance Test

Provide to JPL for approval an acceptance test plan and procedure. Conduct an acceptance test of the hardware and software items delivered in performance of this contract. This acceptance test will exercise these items to demonstrate that they perform the intended function. After completion of the acceptance test, demonstrate operations capability by processing and displaying data from an NTC Exercise History Tape provided by JPL. Notify JPL one week in advance to send a representative to witness this test.

Task 6.0 System Demonstration and Personnel Training

Provide ten (10) copies of the EMC/TAF Operating Manual for the NTC CORE Instrumentation Subsystem (CIS) 500 Player System. Also provide all vendor-supplied training material and operation manuals for vendor-supplied hardware and software.

Upon completion of acceptance testing and the demonstration of operational capabilty, conduct forty hours of on-site training at ARI-POM to provide an intitial operation proficiency. Up to twelve personnel will be accommodated in this training course. The training course will consist of a question and answer format reinforced by demonstration of the system operations; thus, lectures and training plans will be provided.

Provide a one-day, eight-hour refresher course at ARI-POM approximately two months following the initial training course. No new training material will be provided for this course, but SAI will be prepared to answer operational questions. Up to twelve (12) personnel will be accommodated at this refresher course. JPL will provide SAI with a list of operational questions to be covered in this course no later than two weeks prior to the scheduled date for this course.

Task 7.0 Maintenance Support

Provide software maintenance, including the delivery of new software increments associated with formal new software builds provided to the NTC for a period of three months following acceptance of hardware and software at ARI-POM. Provide all relevant NTC documentation updates .performed during the period of maintenance.

APPENDIX H

Final NTC R&D Computer Center Equipment List

August 1984

Appendix H

Final NTC R&D Computer Center Equipment List

Qty	Model	Functional Description
Purchased August 1982:		
1 ea	DEC SV-AXVCA-CA	VAX-11/780 CPU 2 MB ECC Mod Memory
	TU78-AB(AD)	6250/1600 Tape Transport 8 Line Asynchronous Multiplexer
	DU81-CA(CD)	516 MB Fixed Disc Drive & Cabinet
	LA120-DA	Console Terminal VAX/VMS Operating System Compiler
1 ea	DEC FP780-AA	Floating Point Accelerator
1 ea	DEC LXY21-54	132-Col 96 Chr Dot Matrix Printer
1 ea	DEC MS780-DD	2 MB ECC MOS Expansion Memory
1 ea	DEC VT125-AA	Graphic Terminal
Purchased in March of 1984:		
4 ea	DEC VT125-AA	Graphic Terminal
2 ea	Visacon 23	Graphic Processor and 19 in. Color Monitor
2 ea	HDG-403	Digitizing Tablet
1 ea	VPH-722Q	Video Projector
1 ea	VPH-722	Remote Control
1 ea	PSS-10	Projector Support
1 ea	PSS-722	Projector Support
1 ea	CCQ-5-AR	Remote Control Cable
1 ea	B Screen with #23 Brackets	3′ x 5′ Screen
1 ea	H9652-MF	Unibus Expansion Cabinet

Qty	Model	Functional Description
1 ea	MS780-EA	4 MB Memory Expansion Installation
2 ea	DMF-32M	8 Line Direct Memory Access Controllers Installation
2 ea	CK-DMF32-LD	Cabinet Kit
3 ea	FX-100	Epson Printers or Equivalent
6 ea	CITOH101	Terminals Equivalent to VT100
8	1 MB MEM	Memory Boards - STD
2	RA81-AA	456 MB Disk Drive Installation
1	TU78-AF	Magnetic Tape Transport Installation
15	VT220	VT-100 Type Terminals
1	H9652-HA	CPU Expansion Cabinet
1	DW780-AA	Unibus Adapter Installation
1	BA-11KU	Expansion Mounting Box Installation
1	DD11-DK	Expansion Bockplane Installation
1	UNK	Temperature Sensor

APPENDIX I

Considerations in the Establishment and Use of
a Research Data Base for Analysis of Army Training

4 February 1983

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Appendix I

CONSIDERATIONS IN THE ESTABLISHMENT AND USE OF A RESEARCH DATA BASE FOR ANALYSIS OF ARMY TRAINING

2/4/83

Principal Investigator: A. Kroger

Systems Engineering

Section 316

Table of Contents

Abstract

This paper reports the major findings of a study into the utility, creation, and use of a large-scale research data base (RDB) to be used for the post-test analysis of Army training data. The concept was conceived by the Army Research Institute (ARI) as a tool of potential value both in the analysis of training situations and for the development of new training techniques. It would be used to answer questions concerning the soldier's effectiveness in battle situations with particular emphasis on the effect that training has on his tactical effectiveness. The basis for the RDB is test data from the National Training Center (NTC) system. In addition, there is the potential of supplementary training data acquired from other Army record keeping systems. A systematic approach to the definition and use of an RDB is outlined as well as the identification of the criteria for the selection of a Data Base Management System (DBMS) which will be adequate to the needs of ARI. Key points addressed are:

1. The development of a functional requirements statement based on careful analysis of how the Army's needs can best be served by an RDB.
2. The relational characteristics which an RDB must have in order to fulfill its functional requirements.
3. The methodology to be used in order to evaluate the performance of candidate DBMSs.
4. The query language characteristics which are best suited to the ARI researchers' use.

Abstract (continued)

5. An outline of the conversion methodology required for mapping the NTC data base into the RDB in order to create an efficient and expandable research tool.
6. An outline of the team approach required in order to develop a meaningful line of questioning for the RDB.

The following major conclusions are reached in this study:

1. The RDB problem is generic in nature and its successful solution can set a pattern for similar usages throughout the Army.
2. The RDB has great potential value to continuing ARI research.
3. Functional requirements analysis is an essential first step in the creation of an RDB of continuing value.
4. A relational DBMS rather than either a hierarchical or network DBMS is the best solution for RDB processing. The leading candidates for consideration which exist for a VAX relational DBMS are INGRES, ORACLE, IDM 500, NOMAD, and SPIRE.
5. The current lack of specific details on the NTC history file format is a serious impediment to future planning.

I. Purpose and Assumptions

The purpose of this study is to identify the major considerations in the creation and use of a Research Data Base (RDB) to be used by the Army Research Institute (ARI) for analysis of Army training data. The concept is to create an RDB based on the acquisition of historical test data from the National Training Center (NTC) system that can be used to relate any set of variables in the data base. The automation of such a large and complex data base represents a level of analytic capability new to researchers. This will require the development of a new approach which takes advantage of the powe of this state-of-the-art level of automation. The initial analytical steps that must be taken before actual implementation of an RDB can begin are outlined in the sections which follow as well as the criteria for Data Base Management System (DBMS) selection. Finally, suggestions for the continuing use of an RDB are posed.

This analysis was performed without specific details on either the file structure or record content of the software implemented at NTC. The assumption has been made that the builders of the NTC software complied with the requirements laid down in the NTC System Requirements Document (Ref. 1). Since the System Requirements Document is the only source of information about the NTC data base, the analysis and conclusions of this report are limited by the level of detail that was available. It is fortunate that the lack of detail data has not been as much of an impediment to the analysis of RDB requirements as might first appear. This is because a top-down approach to the development of an RDB of value to the Army is iterative in nature and initially requires only an analysis of the uses to which an RDB will be put matched against its generic data content.

II. The Problem

In order to satisfy its need to develop a coherent strategy for improving the combat readiness of its combined armed forces, the Army has established a number of agencies to focus on that issue. The National Training Center (NTC) at Fort Irwin has been set up to train battalion-sized armor and mechanized units in realistic simulated live-fire exercises using force-on-force engagements. The unit (or units) to be trained (the Blue force) are opposed by an appropriately sized home-based opposing force (OPFOR). During the battle training, which may last up to two weeks, a sophisticated instrumentation technology is utilized in order to simulate actual battle conditions and to capture all significant battle data for post-test analysis purposes.

The Army Research Institute (ARI) has been tasked to do basic research in support of the NTC. The starting point for this research activity is the historical data files that are created during the course of a test scenario at NTC. The history files form the basis for both real-time analysis and the After Action Reviews (AAR's). The critique of the units (or unit) being trained occurs shortly after the exercise has been completed and utilizes, in large part, the historical data base to provide the graphics and summary displays created over the entire conflict to demonstrate points on tactical performance. These displays are reproducible through a playback capability for post-test analysis purposes.

While the primary use of the NTC historical data base is to support AAR's, its potential value as a research tool during post-test analysis is equally substantial. Player oriented, it contains not only all pertinent engagement data for the entire battle but also mission, environment, and test controller data inserted during test performance. This latter category is inserted to grade players and identify key events. In order to maximize its post-test analysis value, the massive amount of data that is available to ARI from the NTC instrumented system must be set up in a form that is both flexible and efficient for correlation analysis purposes. This implies the creation of a Research Data Base (RDB) that has the following characteristics:

1. The RDB should bring together in one readily accessible data base all pertinent test data. Access should be possible both thru interactive query and algorithmic programming.
2. The RDB should be capable of enhancement. This means that additional data should be able to be added as required to support the ARI research task without the necessity of either rebuilding or redesigning the total RDB.
3. The RDB should be usable by nonprogrammer personnel. In order to use the RDB most efficiently for planning, researchers must thoroughly understand its data content and be able to formulate ad hoc queries when necessary.
4. The RDB should represent the basis for a substantial portion of the R&D activities that ARI will perform for NTC. As such, it should contain information that is of generic value to the Army in the following key analysis areas:

a) the evaluation of tactics

b) the hypothesis and verification of new measures of effectiveness (MOE)

c) the development of new training methods and techniques

d) particularly as it relates to the effectiveness of new doctrine.

In order to satisfy the tenets of its R&D charter, ARI must learn how to use the RDB effectively once it has been created. This entails the development of a systematic approach to research geared to the automated nature of the RDB. It further implies that ARI understand in advance the functional requirements concerning the RDB and prioritize them so that the basis for future work efforts will be firmly grounded. Finally, there is a need for a publication philosophy that notifies the Army community of all significant findings in order to eliminate redundant effort and maximize the cost-efficiency of the new level of automation.

The RDB concept is at the leading edge of current technology and has the potential of being a tool which can enable ARI to identify problems and suggest solutions well in advance of other Army agencies. Since it is axiomatic that leadership in the area of new technology falls to the one who gets there first, there is a need to move rapidly to acquire an RDB.

To summarize, the judicious specification and use of the RDB can establish ARI as an R&D leader throughout the Army community in the area of the automated tactical and training analysis. The question this paper addresses is - what is the most efficient form for an RDB in order to optimize research into new tactical and training methodologies?

III. NTC Data Base Characteristics

In order to better understand the nature of the problems associated with the creation and use of an RDB, it is first necessary to have a clear understanding of the NTC data base from which it derives and in particular, the History Mode of operation of the NTC system. The Historical Mode of operation at NTC allows for the capture and replay of any portion of a test exercise. The data base which supports this playback capability has, at its focal point, a Player History File that contains all relevant data about each player in the system. This data includes the player's weapon type, position, battle status, unit affiliation, etc. In addition to the Player History File, there is a set of ancillary file structures which support the test and contains the detail parameters that relate to weapon characteristics, commo messages, indirect fire, map data, and other specialized information which has been factored out of the main Player History File. The data is gathered from the instrumented players as the test progresses and recorded in blocks called segments on a history tape.

The history tape is the basis for the graphical presentation of data at monitor controller stations in the NTC system. At any time during or after a test, a graphic presentation of the battle status can be presented on the CRT screen at the monitor controller station. This presentation uses standard military symbology to graphically represent players and is superimposed over a contour map of the area chosen for the training exercise. During an exercise, the engagement characteristics of the battle are presented on the CRT screen as they occur.

The graphic presentation is derived from the Player History File data base. Once initially created, only changes to the Player History File are recorded. A change may be one of position, an engagement event, a player's battle status, etc., and is recordable only if some pre-defined granularity level has been exceeded. The most significant granularities which will affect the post-test analysis capability are the following:

1. The basic history tape time step is 1 second.
2. The minimum player movement recognized by the NTC system is 16 meters.
3. Player position is recomputed by the system once per minute.
4. Statistical data which is also part of a history tape segment and which can be displayed on a special set of status summary displays, is computed every 5 minutes.

An exercise segment may last for a period up to 48 hours with the average duration being 8 to 12 hours. During a segment, the collection of data comes not only from the instrumented players but also from both preplanned mission scenarios which digitize such events as indirect fire sequences, commo messages, etc. and field controllers who can tag key events as they occur. It should also be mentioned that the header data for each segment contains information about the environment, the units participating, and the nature of the exercise that are pertinent to later analysis.

To summarize, all changes are written out for subsequent display and post-test analysis purposes on the history tape. A graphic representation of the Player History File segment format is shown in Attachment A and the History Segment Header nomenclature as shown in Attachment B. The history tapes created during an NTC exercise form the basis for the RDB.

IV. Conceptual RDB Characteristics

Conceptually, an RDB which has the greatest potential for continuing research would contain not only the raw NTC historian file data in a form amenable to retrevial but also a set of enhancements which would allow researchers to do whatever correlation analysis is deemed appropriate. The principal orientation of the RDB is time sequence. In addition to the basic granularity reported, other time subdivisions such as battle stages and key events are of particular interest. The RDB should utilize the existing file structures and field names as much as possible in order to ease the analysis transition from the NTC data base to the RDB (and vice versa).

The most significant data content difference between the RDB and the NTC history files from which it is initially formed, is that the RDB should additionally contain a set of enhancements which allow the researcher to quickly obtain data relationships of interest. The principal types of data enhancement fall into two categories; first, those which are derived from existing data and, second, those which represent the addition of data files from other than NTC sources.

In the first category, algorithmically generated enhancements from the NTC data base that would be of potential value include the following:

1. Redefined categories of battle status related to position, engagement, tactical situation, unit condition, or mission characteristics which are not readily available from a strict translation of the NTC player history file data (see Table 1 for a candidate set of analytic categories).

Table 1: Candidate Analysis Categories and their Attributes of Interest.*

#	Category	Principal Attributes of Interest
1	Player	- weapon, casualty, engagement, training, errors
2	Tactics	- mission, movement, intensity, mobility, support
3	Engagement	- weapon, player, RTCA, range, battle status, training
4	Weapons	- category, fire characteristics, effectiveness, position
5	Position	- relative to other players, plan, terrain characteristics, target, ammo level, movement, tactics
6	Training	- time at NTC, objective, team attributes, individual attributes, engagement, errors
7	Personnel	- experience, education, medical, player, engagement
8	Support	- equipment (player), effectiveness, engagement characteristics, position
9	Mission	- plan vs. actuals (tactics, engagement, weapons, position, commo)
10	Commo	- type, player, time spent, frequency, engagement
11	Environment	- map attributes, visability, day/night, tactics, weather, engagement, errors
12	Team	- unit type, strength, level, engagement summary, training
13	Errors	- tactical, commo, cheating, player, mission, team
14	Control	- unit evaluation, error identification, key event tag, mission, tactics

*It should be noted that all categories appear to be related by at least one attribute to every other category.

2. Analysis factors which would apply to the categorical areas of interest being studied such as ratios, indices, or other performance measures of effectiveness. An example of this latter class of analysis factor would be player density measures (a position function).

3. Redefined units of time granularity that serve either to increase or decrease the time scale or make the retrieval of RDB queries more efficient.

The second general category of desirable enhancements to the RDB is composed of data which comes from sources other than the NTC history file. There are two areas of consideration here. First, there is the addition of supplemental information which fills any gaps left by the test controllers at the time the exercise was being conducted. This would include the completion of segment header data on environment, mission, or unit parameters as well as the incorporation of message content in a processible form which relates to key events, error identification, and unit and player grading. It should be noted that the addition of this type of information to the RDB will necessarily be the result of an in-depth review of the message content from an NTC exercise by ARI personnel. This type of data may well be mappable into one of the analysis factors discussed earlier.

A second kind of desirable data enhancement comes from sources outside the NTC history file and relates to the supplemental information that is pertinent ARI research. This would include such elements as training histories, medical profiles, personnel records, etc. Ideally, such data will already exist in automated files elsewhere in the Army and can be transferred automatically to the RDB. Where this is not the case, ARI should recommend its manual generation and transfer from the appropriate source.

In conclusion, the RDB should be capable of being viewed in as many categorical ways as is meaningful for research purposes. Queries to the RDB should be expressible in terms of analysis categories and their attributes of interest independent of the way in which they have been predefined in the NTC history file. This implies the ability to categorically redefine all exercise components within the RDB for analysis purposes and relate any set of data elements to any other set. The categories and their attributes of interest shown in Table 1 represent a candidate basis for the subsequent analytical work to be done by researchers. While the incorporation of both data redefinitions and enhancements to the RDB should be automated wherever possible, this effort must be initiated as the result of an analysis effort on the part of both researchers and software system analysts. The focus of the analysis effort should be the hypothesis of meaningful cause-effect relationships between (and among) data elements to provide the basis for future experimentation. As an increased insight into the question of what the significant relationships to be investigated in the RDB should be, ARI's ability to formulate better training methodologies will increase also.

V. Selection Criteria for a Data Base Management System (DBMS)

Conceptually, the kind of DBMS that would be most useful for RDB purposes would have the following characteristics:

1. maximize data element relationality,
2. be user friendly,
3. be retrieval efficient,
4. be modularly expandable,
5. be the subject of continuing study on the part of its implementors,
6. be reliably supported.

Each one of these characteristics represents a DBMS selection criterion for the RDB. These criteria are expanded in the paragraphs which follow.

The most important characteristic of an ideal RDB is its relational property. It should have the capability to relate any data element to any other set of data elements contained in the RDB. Because of the importance of this criteria for selection, the conceptual DBMS will henceforth be referred to as a Relational DBMS (RDBMS).

An obvious complement to the desired highly-relational property of the RDBMS is its user-friendly quality. Since a goal of RDBMS use is to enable nonprogrammer personnel to use it with a minimum of training, it should be operationally simple to exercise. This simplicity should extend not only to its query, but also its create, report, and update capabilities. In the query area, the researcher wants to be able to go from an English language question of any complexity to an equivalent set of RDB queries. The ease with which this transition can be accomplished is a measure of user-friendly quality of the RDBMS. It is likewise very important that an efficient mechanism for the creation of an RDB should be provided which enables the use of file structures and formats that are identical to the original source forms. The users must be able to transfer existing files to the RDB directly with a minimum of analytical effort. Finally, there should also be both an efficient means of generating reports and an update mechanism for making corrections to the RDB that is simple to use.

The third major criterion for RDBMS selection is the ability to quickly retrieve complex queries from a large scale RDB. Users will want answers in terms of seconds/minutes rather than minutes/hours. While data element relational flexibility is more important than response time to queries, the importance of the latter characteristic grows in importance as the size of the RDB increases. It should be noted that the key to retrieval efficiency is the data path optimization technique that is used by the RDBMS. The user should <u>not</u> have to describe data paths but rather the system should optimize them based on its knowledge both of data page assignment and the frequency characteristics of individual data fields.

The fourth RDBMS criterion, modular expansion, exists because of the continuing growth characteristic of the RDB. As it increases in size and complexity and as new retrieval requirements are postulated, the RDBMS must be able to cope with this expansion. A mechanism similar to the CREATE function should allow additional data files to be appended to the initial RDB for enhancement purposes throughout the life of the RDB. This entails overcoming the current hardware constraint of not being able to process multiple on-line disk volumes which is a limiting factor for most systems on the market today. A related topic is the ability of the RDBMS to allow for distributed processing; that is, the ability to remotely access, update, and control the RDB or subdivisions of it. Recognizing the fact that distributed processing as a requirement for ARI's RDB has yet to be determined, it is highly likely that once the RDB is operational there will be many agencies remote to ARI in Monterey, California, that will want to use it. If this premise is correct, the modularity questions of capacity and performance will assume greater importance.

The long-term growth potential of the RDB suggests the fifth selection criterion; namely, that the RDBMS should be the subject of continuing study and improvement. Since the RDBMS field is only a few years old, it is not yet clear that the initial products that have appeared in this area are completely adequate for RDB purposes. It is therefore important that the supplier of the RDBMS be committed to a continuing upgrade and expansion of the product. The extent of the upgrading effort can be measured in part by examining both the community of users and the attention given the subject by university sponsored (or user sponsored) studies. It is axiomatic that the more active users of an RDBMS exist, the greater its chances of enhancement. If the only party concerned with the RDBMS upgrade is the company that has created it, the chances that it will keep pace with the state of the art are minimized.

The final selection criterion for an RDBMS is the support level provided by the RDBMS supplier. This should include adequate documentation, training and maintenance. A responsive maintenance capability is of particular significance. In the event of error, the immediacy of a reliable support response on the part of the RDBMS supplier will insure against an RDB loss of integrity.

VI. DBMS Technology Today

Keeping in mind the selection criteria outlined in the previous section, it is appropriate at this point to take a brief look at the state of the art of DBMSs today and to define some of the more important terms. DBMS technology has been the subject of a substantial analytical effort since the early 1960s and a great number of fundamentally different approaches have been implemented across a wide variety of computers. This leads to one of the major difficulties that one encounters when addressing the vast amount of literature on the subject; namely, the lack of consistent definitions across the field. In the paragraphs which follow, an attempt will be made to identify and hopefully clarify some of the major areas of confusion. The topics to be addressed in this section are:

1. Major DBMS classifications - relational, hierarchical, network.
2. Term ambiguity in relational DBMS theory.
3. Query language classification - procedural vs nonprocedural.
4. Major suppliers of relational DBMSs in today's market.

Sifting through the great prolifery of DBMSs on the market, the three major classifications of DBMS that one sees in the literature are relational, hierarchical, and network. It should be noted that while in the DBMS promotional literature they all refer to themselves as "relational," there is a very specific meaning that qualifies a candidate for that classification. It is the flat-file concept that is the basis for file and record structuring, query language design, and output presentation. In the flat-file concept, data are presented to the user as tables instead of hierarchics or networks.

The form of these tables consists of columns and rows, with the rows corresponding to records and the columns representing fields within the records. In the relational DBMS, the internal data storage is not externally apparent. What is important is that the relational view exists at the level at which the user sees the data. Internal access paths and storage techniques are calculated by the relational DBMS system and so are invisible to the user.

The key to relational systems is the formation of new tables by one or more of the following set operations: the combination of existing relational tables (join), the creation of table subsets (selection), or the creation of a subset of the columns in a table (projection). These operations are accomplished by user reference to existing tables through the query language.

Another unique characteristic of a relational DBMS is that there is no explicit path-following mechanism. In other words, the user does not have to predefine the data retrieval paths required, but rather can relate any data field to any other in the data base without first planning the method of access. The relational DBMS will handle the optimization of data retrieval. this is a very significant advantage in relational systems for those cases where it is uncertain in advance the exact nature of the data paths required.

There are two other major categories of DBMS besides the relational: the hierarchical and the network DBMS. In an hierarchical data base, the structure represents the progressive decomposition of data groupings down to the most detailed data element level. The hierarchical data base structure is that needed to support data base application programs [illegible] includes buffer areas, global flags (i.e., end of file), and global pointer variables which hold current pointers to records currently being accessed. For programmer references the hierarchical data base structure is analogous to the hierarchical structure of the COBOL Data Division. The principal guiding force in this area is the CODASYL Data Base Task Group which is chartered to come up with a common approach to structuring of hierarchical data bases (Ref. 16).

The network DBMS, on the other hand, is based upon an analysis of the set relationships which exist among the various data components and the establishment of the pointer chains necessary to access these components. The set relationships are usually outlined in Bachman Diagrams (Ref. 17) and must be known in advance for the kinds of information retrieval that are required. Both the hierarchical and network DBMS are oriented more toward the efficient performance of a limited known set of queries and work in conjunction with a procedural computer language such as COBOL to make the retrieval of subsets of data from a large data base more efficient. In these kinds of DBMS models explicit links or pointers between records in different files replace the relational DBMS method of associating purely symbolic values. It is the responsibility of the analyst to understand the relationships which exist between data elements and to explicitly describe those set relationships. It is then the programmer's responsibility to create and exploit those data structures and the major mode of operation is via handcrafted application programs each performing a specialized task.

The second topic to be discussed is term ambiguity. When relational data base systems are studied theoretically, different terms are often used for the same concept. The following set of definitions may help the reader to sort out the meaning when equivalent terminologies are used.

* Relation = table or record type.
* Tuple = row or record occurrence.
* Attribute = column name or field type.
* Element = field.
* Degree = number of columns in a table.
* Cardinality = number of rows in a table.
* Binary relations = table with two columns.
* N-ary relations = table with N columns.
* N-tuple = a record from a table with N columns.
* Domain = range of values for a specific field.

Armed with the above syntactical equations, the ambitious reader has some chance of equating different systems of ideas in the literature of relational DBMS theory.

The third topic to be discussed briefly is that of query languages. In the universe of query languages, the basic distinction to be made is between procedural and nonprocedural languages. A procedural language is one like FORTRAN or COBOL which enables a programmer to build logical structures to solve problems. These logical structures, called algorithms, may be combined in ever increasing levels of complexity to solve larger and larger problems.

A nonprocedural language is one which focuses on the problem being solved rather than the computer resources being used. A question stated in a nonprocedural language does not represent an analog of the computer logic employed as in the case of a procedural language, but is rather a concise statement of the relationship of parameters under investigation. The principle of the nonprocedural language approach is the smaller amount of effort problem solvers have to exercise in order to arrive at a solution.

In the area of relational DBMS models, there are various levels of nonprocedural language that are significant. They are:

1. Data Definition Language (DDL). The DDL allows for a data base description of table structures within a data base. Through the DDL, both tables (relations) and their fields (attributes) are defined as well as the relationship between tables. This logical description is called a schema and is the first step in the creation of a relational DB.
2. Data Manipulation Language (DML). DMLs accomplish the four basic tasks of inserting new data, removing any old data, updating old data, and retrieving existing data. These capabilities exist in some form in all query languages and hence represent a subset of them.
3. Relational Algebra. This is a form of high-level procedural language which uses basic set functions to act on tables and/or produce tables as a result. The major set functions in a relational algebra are the following:

* Restrict - produces a new table by removing all records that do not meet the specified set of conditions
* Project - produces a new table by removing from each record any attributes not mentioned
* Append - forms a new table by combining two existing tables
* Remove - deletes all specified records which have a specified characteristic
* Intersect - produces a table containing only those records that exist in both of two input tables
* Join - produces a table consisting of all combinations of records which meet a specified set of conditions.

Similar to procedural languages, a relational algebra query is built up as a sequence of operations. Some operations such as JOIN may be difficult to use, however.

4. Relational Calculus. This language form is essentially non-procedural and is based on the basic language of mathematical logic, predicate calculus. Its aim is to permit the user to express what is desired as an answer without having to express how the answer is computed. One form of a relational calculus query is as follows:

FIND < attributes > SUCH THAT < conditions >

where the possible conditional expressions are:

<value> = <value>

<value> > <value>

<value> < <value>

<expression> AND <expression>

<expression> OR <expression>

NOT <expression>

FOR ALL (< variables >) <expression>

FOR SOME (< variables >) <expression>

MEMBER (< variable >, < relation >)

5. Structured English. This approach is similar to relational calculus, but has been further refined to incorporate English-like terminology to make the query language easier to read and write. The standard form was first defined in IBM's query language SEQUEL used with System R. This query form is as follows:

   SELECT < fields >

   FROM < tables >

   WHERE < conditions >

   The structured language approach produces queries that are extremely readable and can be constructed by nonprogrammers with a minimum amount of training.

6. Query by Example. This type of nonprocedural language is graphically oriented and the basic capabilities of a relational calculus are achieved by the manipulation of graphic symbols on a display screen. This is normally done through both the specification of display formats interactively on a CRT screen combined with a set of menus from which operational capabilities are selected.

The final topic to be addressed on the subject of DBMS technology is the identification of the major relational DBMS products for the DEC VAX environment that are widely publicized in today's marketplace. While there may be others of value, the list below represents a sample of the best known. They are listed along with their manufacturer in the following table:

Product	Manufacturer
INGRES	Relational Technology, Inc.
ORACLE	Relational Software, Inc.
IDM 500	Britton-Lee, Inc.
NOMAD	National CSS
SPIRE	NASA Goddard

Leading hierarchical models include the following:

Product	Manufacturer
IDMS	Cullinane Data Base Systems, Inc.
SEED	International Data Base Systems, Inc.
DBMS-10 and 20	Digital Equipment Corporation
Datatrieve	Digital Equipment Corporation

The conclusion one must come to when reviewing the existing state of the art of DBMSs in the light of ARI's RDB requirements is that a DBMS of the relational class which utilizes a nonprocedural language has the greatest potential from ARI's standpoint because it would provide the greatest flexibility and require the least effort to use.

VII. Using the RDB in a Research Environment

Well in advance of the point at which the RDB has been created and is available for research purposes, an understanding of both the data characteristics and the development of an efficient usage methodology should be formulated. On the importance of "knowing the data," it is vitally important that researchers using the RDB get a feel for the relational characteristics between data elements as well as understand the nature of those individual data elements. A thorough understanding of the data characteristics is necessary to obtaining insights into future data manipulation.

On the subject of effective RDB usage, it is imperative that a team approach be developed. The tendency when a resource of this enormous power becomes available is to rely on ad hoc investigations characterized by randomly scattered inquiries as the modus operandi. When one is suddenly confronted with a research capability where the potential exists to be able to answer any question posed to the RDB, it is incorrect to assume that meaningful answers will magically appear without further effort. This is not the case! The hard work of developing a systematic research methodology has just begun.

A systematic approach to utilizing the RDB should start with the development of a specific set of goals which have been prioritized in order to identify the order of problem attack. Each of the goals should be stated in terms of an area-of-interest and should be made as specific as possible in order to help focus subsequent investigative efforts. The research goals and sub-goals that are created represent the work targets to be accomplished and should be the result of a group effort worked out in conjunction with the insights and interests of the entire research staff. The major research thrust should come, of course, from the need to support other Army agencies and ARI must become increasingly sensitive to areas where RDB research can be of benefit. The emphasis on a team approach to goal creation will help to develop, on the part of each researcher, a sense of how individual research activities fit into the master plan.

After a group understanding has been reached for both the goals of the research program and the method of attack on the RDB, the time has come to begin hypothesizing alternative research premises and evaluating them. The use of "what if" group thinking should create an environment where the spectrum of potentially valuable lines of investigation will be identified. Each what-if line of thought should be carefully posed, reviewed, and critiqued. A top-down approach to problem statement should be used. This means that a potential line of investigation should first be posed in its broadest terms and then decomposed into successively lower levels of more specific inquiries until the point is reached where specific questions can be asked of the RDB using the RDBMS. The value of the answers received should be predictable in advance although the actual answers that develop may come as a surprise.

The principal use of the RDB will be in correlation analysis; that is, in the study of the interrelationship of RDB variables. Central to RDB use is the investigation of cause-and-effect in terms of the functioning of the tactical entities of the RDB, particularly as they relate to training. Insights gleaned from past exercises can become training hypothesis whose implemented premise effects can be studied in subsequent exercises. The resulting linkage of test analysis, training hypothesis, new training method, new test result can provide a new evolutionary training methodology based on automating the NTC exercise experience.

The cycle of RDB use runs the gamut from idea conception, to experimental hypothesis, to premise implementation, to result verification and may span multiple NTC exercises. It should be noted that in the area of premise implementation, there are three major categories of activity. They relate to the implementation of one of the following: training recommendations, NTC system improvements, or tactical recommendations. The RDB can be viewed as the test-bed for the validation of experimental hypothesis originating from an initial correlation analysis of individual functional properties. This view, of course, considers the NTC testing sequence as an integrated whole rather than as isolated training exercises.

A final important concept is the publication of all significant findings of RDB research on an Army-wide scale. Since the work that ARI will be doing with the RDB has broad implications, all significant findings should be passed on to others who may profit from ARI's experience. The wide-scale adoption of the techniques and findings into training and tactics methodologies developed using the RDB can represent a substantial cost saving to the Army.

In summary, the key to success in the use of the RDB is <u>the organized rather than the shotgun approach</u>. This means the avoidance of the random ad hoc query method except in support of specific lines of inquiry. It further implies the group formulation of a systematic approach to research in which all team members have a common understanding as to both the functional and the statistical characteristics of the RDB. Because the RDB represents a large and complex set of data, it is obvious that the better the content and functional interrelationship among the various data elements are understood, the more astute the lines of investigation will become. The systematic group attack on the research activity characterized by continuous feedback through skull sessions and the publication of the valuable insights gleaned from the RDB should put ARI in a position to generally assist Army planning activities.

VIII. Asking the RDB Questions

Central to the problem of retrieving meaningful data from the RDB is the way in which it is asked questions. The development of an understanding of what can and what cannot be extracted as well as the best methodology for question formulation is essential to effective RDB utilization. In recognition of the fact that the question is the key, the essentials of posing RDB queries are outlined in this section.

Questions asked of the RDB should represent lines of thought whose answers have significance to training, tactical considerations, or NTC system operations. The individual questions should first be written in English in a free-form format and afterward translated into a set of RDBMS queries (or a single RDBMS query). The question should be as specifically directed as possible, as simple as possible, and the meaning of its answer should be clear. The recommended SELECT...FROM...WHERE... format should be used to access the RDBMS. (This format has already been discussed in Section VI.) If the variable relationships posed in an RDBMS query are too complex, the meaning of the answer will be unclear. In the search for significant functional relationship between and among RDB variables, simplicity is a virtue.

The limit of questioning is constrained only by the limits of the RDB. If it does not contain the data needed to answer a question, steps should be taken to enhance the RDB by the addition of that data. It should also be remembered that a single question can give only a limited answer. Its significance lies in its contribution to the line of thought that is being investigated. In phrasing a question, the researcher should avoid the tendency of single question complexity to avoid the risk of not knowing what the answer means.

The query format that is recommended for the posing of questions to the RDB at the RDBMS level is the structured English approach outlined earlier which has general acceptance in relational data base theory and has been implemented as a standard relational calculus input into the major systems offered today. It is in the form:

SELECT (data element list)
FROM (tables where data exists)
WHERE (conditions under which retrieval is to be made)

This form identifies in the SELECT clause the exact RDB elements to be either collected or counted. The FROM clause indicates the tabular subset of the RDB that is to be accessed. The WHERE clause enumerates the conditions under which retrieval is to take place. Conditions in the WHERE clause should be posed in terms of either the boolean operators (AND, OR, NOT) or the relational operators (=, =, <, >,= <, > =) as they apply to RDB data elements used to constrain the search. It should be noted that while the actual query syntax for implemented RDBMSs may differ slightly (the QUEL language developed by Relational Technology uses RETRIEVE instead of SELECT), the relational properties of all structured English level languages contain the same essentials and are more user-friendly and require less technical knowledge than either the hierarchical or network class of DBMS inputs.

The questions posed to the RDB should be initially stated in more general English rather than in the specific SELECT...FROM...WHERE... format required by the RDBMS and while they should be free-form in nature they nevertheless should name actual data fields. No constraint should be initially imposed on the relationships of interest and the difficulty of retrieving the desired information should not be considered. For example, an initial question might be phrased as follows:

"Retrieve all instances where a sagger missle killed a tank within a 1-minute time period for each type of Blue Force maneuver after an indirect fire scenario sequence."

It is important that each key phrase in the question be carefully defined. In the preceding sample question, the concepts of time period, maneuver, and indirect fire must be clearly understood so that precise data relationships can be established. The ease or difficulty in putting a question into a format acceptable to the RDBMS should be secondary to the query consideration of whether or not it represents a meaningful line of thought. Emphasis should be placed on what the answer means. It should be noted that the fact that there may be retrieval difficulties associated with a question should also not initially be a constraining factor. Any retrieval difficulties which are uncovered merely serve to identify algorithmic processes which may be required to be developed.
For example, in order to answer the following question, an algorithmic two step process is suggested.

"Show the ratio of instances where a player has been killed or wounded while moving in graduated proximities to contour for each type of mission."

After defining all important terms in the question, the next step might be to develop a set of positional indices for each player which describe his position relative to contour lines. This would identify a preprocess which matches the X-Y coordinates of the player's position to the map data base in order to develop a height (or Z) parameter. A following step would be to ask questions of the RDB using that parameter as a conditional variable. This multiple step process will allow map complex questions to be answered as they relate to tactics.

On the other hand, the following question may be directly calculatable in a conditioned RDB:

"Show by weapon type the number of kills, hits, and misses when a target was stationary for at least two minutes and a deliberate attack was in progress."

As a standard relational calculus input to an RDBMS, that query might appear as follows:

```
SELECT (T-52 [tank], BMP-W-SAGGER, 122MM-SP [howitzer], MANPACK-
    W-SAGGER, MORTAR, CHEMICAL, BIOLOGICAL, FIGHTER-BOMBER, STATUS
    [personnel], MOVEMENT-INDEX [time oriented], MISSION-CODE)
FROM (PLAYER-HISTORY-FILE, PERSONAL-STATUS-FILE, MOVEMENT-INDEX-FILE)
WHERE (WEAPON-TYPE = T-52 or WEAPON-TYPE = BMP-W-SAGGER or
                         o
                         o
                         o
```

WEAPON-TYPE = FIGHTER-BOMBER

STATUS = K/A

STATUS = W/A

MISSES = INITIAL-BY-WEAPON-HITS

MOVEMENT-INDEX < 2

MISSION = DELIBERATE-ATTACK)

In this example, the square brackets [ ] enclose comments while the capitalized mnemonics identify fields or files. It is further assumed that the category, HITS, has been collected either during the course of the exercise or in a post-processing step.

In summary, queries to the RDB should evolve from a general line of questioning which it has been determined in advance will lead to an important conclusion. The starting-point question should be stated as an English sentence and name actual data base elements. While initially it may be of great complexity, a set of specific questions tailored to the RDBMS should next be derived which will pinpoint a data correlation of value. Questions should always be considered in terms of - what does the answer mean? Queries presented to the RDBMS should be kept as specific as possible. In the event that there is no direct answer, the question may reveal an algorithmic process that needs to be developed. In such a case, a preprocessing step may have to be provided to develop the proper algorithms which will condition the RDB to get the answers required.

IX. RDBMS Output Characteristics

The principal characteristic of RDBMS output is that it will consist of as many user "views" of the data as is required. The basic view is a tabular format consisting of an enumeration of all pertinent data elements which satisfy a given set of conditions. These views are all independent from one another and may be either a count of instances or a listing of those instances in a report form. For specialized report formats which may include subtotals, the RDBMS should incorporate a report generator. A sample report format based on the final question asked in Section VIII might appear as follows:

JAN 14, 1983

SUMMARY OF WEAPON EFFECTIVENESS

DURING A DELIBERATE ATTACK MISSION

FOR UNIT XYZ

	T-52	WEAPON BMP W/SAGGER	TYPE	FIGHTER-BOMBER
KILLED IN ACTION			. . . .	
WOUNDED IN ACTION			. . . .	
% EFFECTIVENESS*			. . . .	

*NOTE: % EFFECTIVENESS IS THE RATIO OF $\frac{K/A + W/A}{\# \text{ OF FIRINGS}}$

In addition to the standard hard copy report format, a summary version which represents a count of instances should be viewable at a CRT. Moreover, the RDBMS should also be able to produce graphic output which relates either two or three variables in a graph, bar chart, or pie-section format. Since retrievals should also be able to be made from computer programs as well as CRT consoles, the records returned from queries should also be available in a form that is algorithmically processible by a procedural language such as FORTRAN.

It should be noted that the output forms can contain ratios or indices as possible measures of effectiveness and these ratios may be computed either at retrieval time or as the result of conditioning the data in advance. As pointed out earlier, the latter alternative has benefits both in terms of shortened retrieval time to queries and added query flexibility; i.e., more complex functional relationships between variables can be investigated although it does serve to increase the size of the data base.

A simple count of instances, i.e., the number of times something happened, provides the simplest type of output and has great significance in the determination of the frequency characteristic of data elements within the RDB. This frequency data is also of value to the RDBMS which uses it (or should use it) as an input into the algorithmic process for fine-tuning the retrieval process.

The basis of the correlation process is the comparison of two variable relationships. The classic laboratory experiment which takes the $y=f(x)$ form with the universe of other variables held constant is familiar to all students.

The introduction of a third variable increases the relational complexity but may still be conceptually meaningful and can be shown in graphic form (see Attachment C for sample of INGRES graphic outputs). When an attempt is made to deal with more than three variables at one time, the additional variables can only be used to control the environment which yields the answer. Remember that the questions which must be posed for every line of inquiry are: first, what are the premises and, secondly, what does the answer mean? In order to get data correlation that makes sense, the query to the RDB should normally be posed in a two variable $y=f(x)$ format with multi-variable conditions used to establish a controlled environment. The resulting answer will be a standard view which either enumerates or counts instances and provides values for the pertinent data elements.

In the area of evaluating NTC operational procedures, an important use of RDBMS output will be in the identification of missing data for the purpose of achieving a more effective post-test analysis program. In order to carry out this task automatically, gaps in the data should be searched for explicitly and, in those found instances, the missing data supplied. The missing data being discussed represents control, evaluation, or key event information. Output which identifies any lack of such data should result from a judicious set of RDBMS queries targeted at the absence rather than the presence of such information. When a pattern of data omission can be identified, a recommendation to NTC to correct the operational procedure should be made.

The effect of new training or tactical procedures can also be examined as it compares to expected results from prior test scenarios. This implies the continued use of the RDB across unit tests which would result in an evolutionary advance in RDB use. There is every likelihood that the RDB may be able to provide in a concise output format the experimental proof necessary to verify the effectiveness of both a new training and new tactical methods.

X. Creation of the RDB

The first step in the creation of an RDB is the definition of the RDB's functional requirements. This activity identifies not only the direction that future ARI efforts will take, but also any limitations to be imposed on those efforts. The identification of the functional requirements for an RDB is closely tied to the setting of goals for the program. ARI must define the organizational needs before steps can be taken to obtain solutions. A derivative of goal setting is the identification of constraints arising from both functional and cost considerations. Once a satisfactory definition of functional requirements has been identified and published, the task of building an RDB can begin.

The next step in the creation of an RDB involves the conversion of the existing NTC history tapes. Before the actual conversion process can begin, several analysis activities should be undertaken. As a starting point, the exact format of the data must be identified to enable the transcription process to the appropriate RDBMS format to take place. This will normally take the form of the data element parameterization of a COPY function which transfers file data from the NTC to the RDB using RDBMS system format conventions.

The selection process for an RDBMS should occur either before or in parallel with the analysis of the NTC history tape content. These activities are independent because, while there will be minor syntactical and operational differences, all RDBMSs which use structured English (the recommended query syntax) have the same generic input file format. Both the data content of the NTC tapes and the functional capabilities of the candidate RDBMSs should be understood in order to design an efficient mapping strategy from the NTC history tapes to the RDB.

An important step in that mapping strategy is the analysis of the frequency characteristics of data elements within an NTC history file segment. Since only changes to current status are written out by the NTC system, the mapping from the NTC data base to the RDBMS data base may require an intermediate step in which a set of fixed length records are created for each type of transaction (or change). Each transaction type would then be sortable into its own standard file structure. One advantage to this approach would be that the frequency characteristics of each class of data transaction could be derived in the translation process.

A related area of analysis is the determination of the degree to which file structures within the RDBMS should be created to make the best use of the frequency characteristics of the data to maximize retrieval time and minimize to disk space taken for the RDB. It may well be the case that categorical distributions naturally occur which were not a part of the NTC system data base definition and yet which are of value to the RDBMS.

One area of analysis which should be performed prior to conversion has to do with the possible redefinition of meaningful measures of both time and positional granularity. As a part of the general problem of data reduction, the following questions arise and must be answered:

1. Should a one second granularity be retained as the basis of analysis?
2. Independent of the answer to question 1, are there higher levels of time granularity which are of value for analysis purposes?
3. Are there other measures of positional granularity that are of value?

As the result of the answer to these granularity questions, it will be possible to identify a set of data augmentations of analytical value to ARI. The concept of granularity may apply to other set definitions besides time and position and is relevant to any categorization which is appropriate for analysis purposes and for which data has been collected (see Table 1).

Another important area of analysis which should be undertaken as a part of the conversion process relates to the conditioning of the basic data captured by the NTC system to create a continuous set of additional measures of effectiveness in the area of indices or ratios of performance. Where it is possible to calculate such performance indices at retrevial time without great loss of efficiency, they should not be considered as candidate RDB augmentations. However, where useful indices require a pre-processing step or would create a time-consuming calculation burden at retrieval time, their incorporation as data into the RDB should be considered.

The actual data conversion itself should be composed of the following conceptual steps:

1. The mapping of the NTC data tapes into a set of individual transaction files based on change frequency discussed earlier. This may require the packing of change data into fixed length format with null fields introduced to complete the record structure.
2. A study of the reduction properties of all data to be incorporated into the RDB with the intent of space saving and retrieval time economy.
3. The specification and algorithimic incorporation of all time, positional, or other granularity redefinitions of value. This should occur for each intermediate-step transaction file.
4. The specification and algorithmic incorporation of all performance ratios or indices deemed necessary to incorporate into the RDB as basic data.
5. The creation of explicit indices in those cases where implicit pointers to ancillary tables are used.
6. The provision of any ancillary data required for display purposes.
7. The description of all data formats and file structures into a Common Data Dictionary which is independent of any candidate RDBMS selected.
8. The execution of the COPY function to create a preprocessed file structure that is optimized from a retrieval standpoint for the RDBMS.

Once the RDB has been created, further enhancements relate to either supplying missing test data or adding entirely new data to the RDB from other sources. In the area of supplying missing information about a test under scrutiny, the type of data to be added may relate to such things as environmental conditions, mission planning, tactical events of significance (key events), performance evaluation parameters input by field controllers, training parameters, etc. Field controller inputs of value may be in nonprocessible form (source commentary) and it may be desirable to translate them into processible variables. It should be noted that this type of data enhancement involves a high degree of judgmental analysis. In order to accomplish this class of data augmentation, there should also be a careful review of both the digitized and audio commentary provided by the field controllers.

A second class of RDB enhancement relates to the addition of entirely new data to the RDB such as personnel and unit training records. .The existence of valuable supplementary data may well exist in automated form on other computational systems within the Army community of data processing. Where this is the case, such data files should be copied and incorporated in the RDB in order to enhance both its power and generality.

While data base configuration management issues are the subject matter of another paper, a word should be said on the system backup for the RDB. The steps in the conversion process should be carefully documented in a set of cookbook-like procedures so that the RDB can be reconstituted in the event that its integrity becomes suspect. This entails not only saving the original NTC data tapes (or a compacted copy of them) but also maintaining a careful record of all enhancement, additions, and changes that may have occurred. In the worst case, the RDB should be recoverable from scratch using a set of well documented standard procedures which govern the intermediate mapping process.

A final word should be said on some topics not covered in this discussion which represent additional areas of analysis that must be considered before the conversion procedure takes place. They are:

1. Updating the RDB

2. Security considerations

3. The validation of RDB data.

Each of these topics should be reviewed and a strategy developed which matches the functional requirements of the RDB.

XI. Continuing Areas Of Study

Once the RDB has become operational at ARI, continuing areas of study involving the RDB lie in essentially five areas. In outline form they are:

1. Correlation analysis. This involves the continuing study and understanding of the relationships involved between and among the variables which make up the RDB.
2. RDBMS retrieval optimization. The principal areas of continued investigation here lie in the restructuring and the conditioning of the RDB elements to maximize the data retrieval capabilities of the RDBMS while at the same time minimizing the capacity requirements of the RDB.
3. RDB enhancement. This area of continued study should be focused on three sub-categories. First, the addition of data elements either left out or in non-processible format inherent in the NTC tests which are complementary to analysis. Secondly, the addition of algorithmically created data elements which make the retrieval process more general in terms of response capabilities. Principal concerns here are revised time and position granularity questions particularly as they relate to key events. A third area of data enhancement focus should be the addition from entirely new sources not only unit and individual training data but also tactical and mission planning data. This class of addition will be useful in evaluating the results of experimental hypothesis as well as verifying basic correlations between data elements not previously relatable except through unsubstantiated insight.

4. Basis for experimentation. The RDB can be used on a continuing basis as the test-bed for experiments in both the training and tactics areas. The statistical results that it provides will enable the verification of a wide variety of theoretical premises of interest.

5. Modeling. Performance profiles may be extracted from the RDB that are the basis of either tactical or training models. Care should be taken, however, not to combine past historical data with future estimates of performance in ways that are not meaningful.

XII. Conclusions

1. The RDB problem is generic in nature and its successful solution can set a pattern for similar usages throughout the Army.
2. The RDB has great potential value to continuing ARI research.
3. Functional requirements analysis is an essential first step in the creation of an RDB of continuing value.
4. A relational DBMS rather than either a hierarchical or network DBMS is the best solution for RDB processing. The leading candidates for consideration which exist for a VAX relational DBMS are INGRES, ORACLE, IDM 500, NOMAD, and SPIRE.
5. The current lack of specific details on the NTC history file format is a serious impediment to future planning.

XIII. Recommendations

1. ARI should develop a systematic team approach to the creation and use of the RDB which provides a general understanding of the goals of the program.
2. ARI should immediately begin consideration of possible lines of questioning to be addressed to the RDB.
3. The question of combining the RDB across unit tests at the lowest level of granularity should be carefully reviewed since there are not only retrieval tradeoffs but serious utility questions to be answered on that subject.
4. The selection of the RDBMS should be based on an analysis of competing characteristics. The most accurate way to do this is to field test each candidate using a complete NTC exercise and a representative set of queries to it. It is more expeditious, however, to analyze the leading candidates, select the one that appears to have the greatest capability for ARI's purposes and then target the conversion to that RDBMS. If subsequent candidate comparison is desirable, it can always be done at a later point if the first candidate selected proves inefficient. In addition to its performance and flexibility characteristics, the extent of current usage should also be a selection factor. This is because the extent of usage is an approximate measure of both the reliability and future performance extensions to the current DBMS version.

5. ARI should immediately take steps to acquire the format details of the history data files from NTC which form the basis of the RDB so that further planning can occur.

6. ARI should adopt an implementation plan for acquiring an RDB which approximates that shown in Attachment D.

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ATTACHMENTS

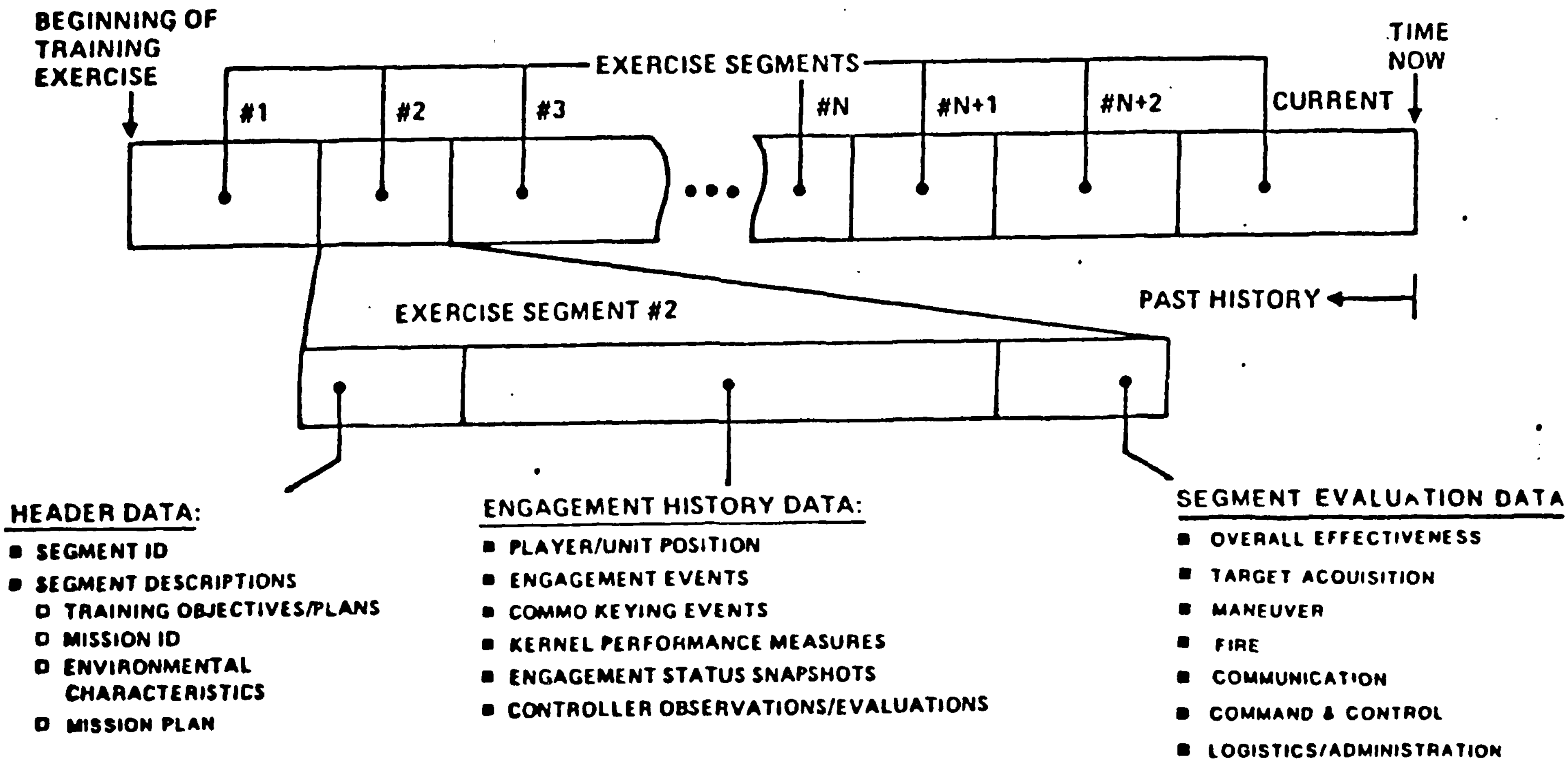
A - NTC Player History File Structure

B - History Segment Header Nomenclature

C - INGRES Graphics Package Summary

D - Implementation Plan Outline, Schedule and Rough Manpower Estimates for Acquiring an RDB

(0154a)



ATTACHMENT A: NTC PLAYER HISTORY FILE STRUCTURE.

Dy WABBCC
.. Day BB Month CC Year

BLUFOR SCENARIO #: XX
XX 2 Digit Code Number (up to 50 scenarios)

OPFOR SCENARIO #: XX
Intensity Index Code:

	BLUE	OPFOR
Planning Time Available	XX	XX
Fire Support	XX	XX
Artillery	XX	XX
Mortar	XX	XX
Nuclear	XX	XX
Chemical	XX	XX
Biological	XX	XX
Smoke	XX	XX
Air Defense	XX	XX
Engineer	XX	XX
EW	XX	XX

Where XX = a numerical character for 01 = Low, 02 = Medium, and 03 = High

KEY TRAINING OBJECTIVE CODE #s: AABBCCDDEE
Where the Key Training Objectives (of all scenarios) are assigned 2 digit code #s, e.g., AA, up to 25 key objectives can be assigned a code. Up to 5 key Training Objectives can be tagged in the History Segment.

VISIBILITY CODE: W
W 1 Digit Code where 1 = Clear, 2 = Dust, 3 = Fog, 4 = Rain

DAY/NIGHT CODE: Y
Y 1 Digit Code where 1 = Day, 0 = Night

Bn DESIGNATION: X-XXXAAA
Where X are numerical designations and A is alpha characters to indicate type Bn, i.e., INF, ARM, CAV

Bn DAY AT NTC: XX
Where X = numeric (1-14) of the days spent so far at NTC

Bn TIMES THROUGH INDICATED SCENARIO: XX
Where X = numerical value representing number of times this unit has run this scenario

ASSIGNED/ATTACHED UNITS LIST: (Up to 8 Units)
Unit #1
Unit #2
Unit #3 Where AA are alpha characters for letter designators A, B, C, HQ, CS - PA would indicate platoon of A co
Unit #4
Unit #5 X-XXX are numerical designators for parent battalion of unit
Unit #6
Unit #7
Unit #8

TYPE OF OPERATION/MISSION CODE:

Battalion Level Code:
BXXYY where B = Bn, XX = Mission Code #, YY = Operations Modifier Code

Bn Mission Codes:
01 Movement to contact
02 Hasty attack
03 Deliberate attack
04 Exploitation and pursuit
05 Reconnaissance in force
06 Raid
11 Defend in sector
12 Defend from a battle area
13 Delay in sector
14 Delay forward of a specified line for specified time
15 Disengagement
16 Counterattack

Operations Modifier Code:
01 Passage of lines
02 Relief in place
03 Road march
04 Occupation of assembly area

COMPANY LEVEL CODE:
WCXXYY where W = Unit # (1-8) from Assigned/Attached unit list. C = Company, XX = Mission Code #, YY = Operations Modifier Code #

Company Mission Codes:
01 Movement to contact
02 Hasty attack
03 Deliberate attack
04 Exploitation and pursuit
05 Raid
11 Occupy a battle position
12 Hasty defense
13 Deliberate defense
14 Defend to retain a battle position
15 Hasty defense
16 Deliberate defense
17 Create and defend a strongpoint (deliberate defense)
21 Patrol operations

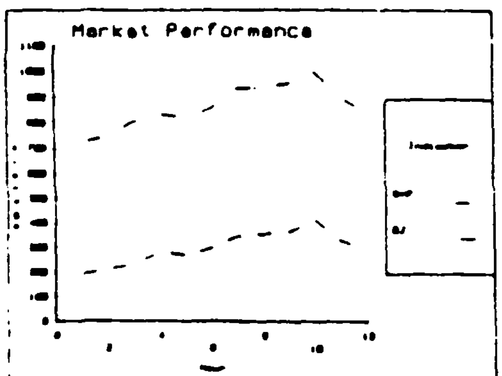
Operations Modifier:
01 Passage of lines
02 Relief in place
03 Road march
04 Occupation of assembly area

Additional Tags Code:
XX where XX=2 digit code for up to ten additional tags that are defined in a list in the data base

A history segment will be defined by the EMC operator by assigning a start time along with the various tags defined above. History segments can be event driven (a phase of a scenario) rather than defined by time. At the end of a history segment or phase of a scenario the EMC operator would simply close the segment and start a new one.

Relational Technology Inc. (RTI) announces the introduction of INGRES GBF (Graph By Forms), available as an add-on module with Version 2.0 for VAX/VMX. Designed by INGRES Technical Staff member John Newton, GBF translates information in an INGRES database into a variety of easily understood graphical depictions. The GBF package is designed for the decision maker in business and scientific situations.

The GBF package best accommodates environments where the need for a clear *picture* of trends, exceptions and implications in crucial data outweighs the need for each explicit data item making up the general picture. Two basic components make up the package. The first is the **gbf** facility, a "visual programming" tool with which users specify what kind of graph they want and the sorts of features they wish. GBF presents a range of screen-based forms with command menus to the user. In turn, the user fills in the forms and selects menu options that specify the graph's characteristics. GBF stores the results of these specifications in system catalogs in the database. The second component, the **graph** command, generates the graph according to the user's specifications as built with the GBF facility.



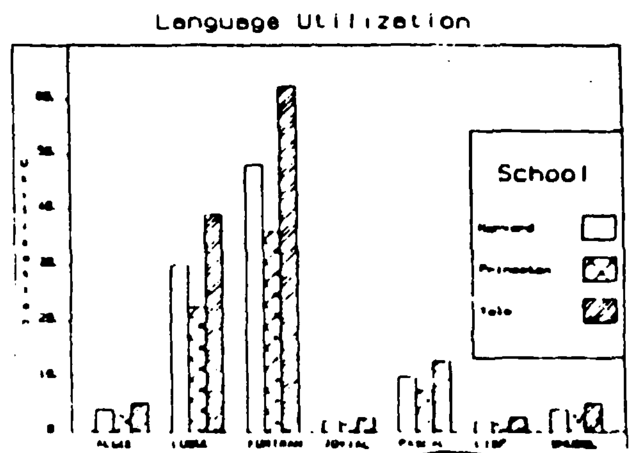
The logic of INGRES GBF mirrors that of the INGRES Report Writer. The **gbf** command records graph specifications in the database, just as the **sreport** command records report specifications. The **graph** command outputs the user-specified graph either to an appropriate terminal or plotter, just as the **report** command outputs the user-specified report.

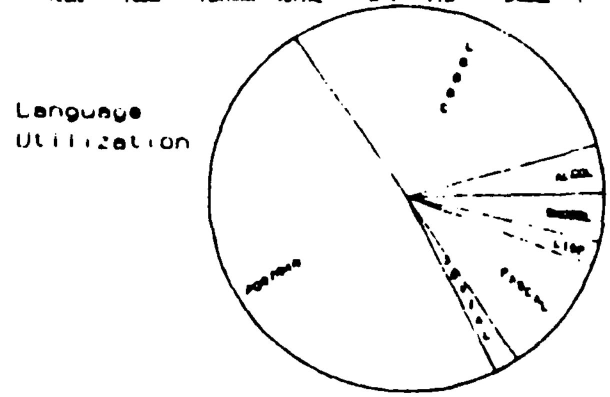
In its initial release, GBF allows users to select a variety of characteristics for a graph. These characteristics include the following:

- The *data set*, or information to be graphed, specified with a QUEL (INGRES QUEry Language) statement that retrieves relevant rows from the database,
- The *graph type*, including bar charts, pie charts, scatter plots and general line graphs, and
- A wide range of additional features, including (but not limited to) headings, legends, cross-hatch patterns, dot types, line types, type faces, titles, linear regression for scatter plots, scales for quantities including a logarithmic scale and tick marks for various scales.

The first release of INGRES GBF is supported on a variety of devices

- Terminals—DEC's VT125, the Tektronix 40xx series and graphics terminals compatible with them, such as the AED 512/767, RAMTEK 62xx series, Chromatics and Envision. A range of other alphanumeric terminals (not including DEC's VT100 terminal) also support INGRES GBF.
- Plotters—Zeta, Calcomp and a range of Hewlett-Packard plotters.
- Film recorders—the Dicomed film recorder, to generate slides of graphs.





A full list of supported terminals, plotters and film recorders will appear in the release documentation.

The first release of INGRES GBF will produce monochromatic, two-dimensional graphs. The following release, Version 2.0 for VAX/VMX, will support three-dimensional images, color and other features for "boardroom quality" graphics. Future plans include an interactive graphics editor, with input graphics devices such as light pens, mice, crosshairs and track balls.

RTI distributes the INGRES GBF package as an unbundled item for $2500. Complete details on pricing, support, updates and related issues are available from RTI. ■

Attachment D. Implementation Plan Outline, Schedule, and Rough Manpower Estimates for Acquiring an RDb.*

Item	Task Description	Year 1 1 2 3 4 5 6 7 8 9 10 11 12	Year 2 1 2 3 4 5 6 7 8 9 10 11 12	Approx. Man-Years	Notes
	Phase II				
1.0	DB requirements analysis	*---------* (months 1–6)		3.0	The RDb can be created from NTC tapes independent of the installation of the play back system at ARI. All that is needed are the data tapes.
1.1	Reduction				
1.2	Augmentation				
1.3	Structure				
1.4	Prioritization of study topics				
2.0	DB design spec	*-----------* (months 7–12)		3.0	Design should start as soon as the functional requirements have been specified.
2.1	General approach				
2.2	RDBMS candidate selection				
2.3	Common Data Dictionary design				
2.4	Algorithm design				
2.5	NTC to RDB mapping tool				
2.6	Acceptance test of mapping tool				
3.0	Create RDB		*---------* (months 1–6)	3.0	
3.1	Build RDB mapping tool				
3.2	Create CDDcandidate to be				
3.3	Execute mapping & test				
3.4	Acceptance test				
3.5	Document				
	Phase III (TBD)		*----------> (from month 6)	?	The extent of the Phase III effort will only be definable at the end of Phase II.
	Total Effort Phase II (approx.)			9.0	The 9 manyear effort is spread over 1-1/2 years. No breakdown of contractor vs ARI personnel has been made.

*THIS IS <u>NOT</u> AN OFFICIAL JPL TASK ESTIMATE OF SCHEDULE AND MANPOWER!