GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

PROJECT ADMINISTRATION DATA SHEET

Project No. A-3061
DATE 9/21/81

Project Director: Mr. Edward J. Shanahan, Jr. School/Lab ECSL/CCB

Sponsor: US Army Communications - Electronics Command (CECOM)
Ft. Monmouth, N.J.

Type Agreement: Contract No. DAAK80-81-C-0175

Award Period: From 9/9/81 To 3/9/82 (Performance) 3/9/82 (Reports)

Sponsor Amount: $49,799

Cost Sharing: N/A

Title: Data Base Processing Development Plan for SIGMA

ADMINISTRATIVE DATA

1) Sponsor Technical Contact:
Robert Derner
US Army Communications - Electronics Command
Ft. Monmouth, NJ 07703

2) Sponsor Admin/Contractual Matters:
Thomas A. Bryant
US Army Communications - Electronics Command
Ft. Monmouth, NJ 07703

Defense Priority Rating: DO-A7 under DMS Reg. 1

Security Classification: SECRET

RESTRICIONS

See Attached GOVT Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval – Contact OCA in each case. Domestic travel requires sponsor
approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with Government, however none proposed.

COMMENTS:

COPIES TO:
Administrative Coordinator
Research Security Services
Research Property Management
Legal Services (OCA)
Accounting
Library
Procurement/EES Supply Services
EES Public Relations (2)
FORM OCA 4:781
Project Title: Data Base Processing Development Plan for SIGMA

Project No: A-3061

Project Director: Edward J. Shanahan, Jr.

Sponsor: US Army Communications - Electronics Command (CECOM)

Effective Termination Date: 4/30/82

Clearance of Accounting Charges: 4/30/82

Grant/Contract Closeout Actions Remaining:

☐ Final Invoice and Closing Documents
☐ Final Fiscal Report
☐ Final Report of Inventions
☒ Govt. Property Inventory & Related Certificate
☐ Classified Material Certificate
☐ Other ______________________

Assigned to: ECSL/CCB (School/Laboratory)

COPIES TO:

Administrative Coordinator
Research Property Management
Accounting
Procurement/EES Supply Services

Research Security Services (OCA)
Reports Coordinator (OCA)
Legal Services (OCA)
Library

EES Public Relations (2)
Computer Input
Project File
Other ______________________

FORM OCA 10:781
Mr. Robert Derner  
Office of the Project Manager, OPTADS  
Attention: DRCPM-OTDS-TM  
U.S. Army Communications - Electronics Command  
Fort Monmouth, New Jersey 07703

SUBJECT: Deliverable Number 1, September Monthly Status and Cost Report  
REFERENCE: Contract Number DAAK80-81-C-0175 (A-3061), Data Base Processing Development Plan for SIGMA.

Dear Mr. Derner:

This is the first of a series of reports addressing the status of and plans for the reference contract. This report covers the period September 9 thru 30, 1981.

STATUS

The work indicated below was conducted during the reporting period.

1. A meeting was conducted in Fort Monmouth with OPTADS personnel to discuss the scope of the project. It was concluded at that meeting that:
   a. One DBMS will be selected;
   b. The preferred BMS should be commercially available and require minimal modifications;
   c. A goal of fast output (or retrieval) was established;
   d. The planning function of SIGMA is the target for implementation;
   e. A single (vice distributed) data base at division level is the objective system for this project;
   f. The DBMS which will be exercised in the field in Europe should be implemented in eighteen (18) months; and
   g. Key to the effort is maintaining the capability to evolve the selected DBMS on a continuous basis to the SIGMA objective DBMS;
2. Investigations into the myriad of DBMS were initiated to get a greater understanding of the capabilities and limitations of commercially available systems. In addition, technical review of the Tactical Computer System/Tactical Computer Terminal (TCS/TCT) operating system was started. This latter effort is important as the selected DBMS must interface with the TCS/TCT.

3. Also initiated were investigations into the nature of the information which will be handled by the DBMS. This work addresses the data structures, information retrieval criteria, and other such user oriented factors.

PLAN

The following will be conducted during the next report period.

1. Identification of parameters to be used in selection of a DBMS.

2. Continue of the review of the commercially available DBMS and the TCS/TCT operating system.

3. Continue to review the information structure of the SIGMA system in terms of the planning function.

PROBLEM AREA

No major problem areas were identified.
FUNDING STATUS

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Sincerely,

Edward J. Shanahan, Jr.
Project Director,
Command and Control Programs
Electronics & Computer Systems Laboratory

Approved:

K. Bennett Teates,
Head,
Command and Control Programs
Electronics & Computer Systems Laboratory

EJS/HBT:dar
November 9, 1981

Mr. Robert Derner  
Office of the Project Manager, OPTADS  
U.S. Army Communications - Electronics Command  
Fort Monmouth, New Jersey 07703

Attention: DRCPM-OTD-TM

SUBJECT: Deliverable Number 2, October Monthly Status and Cost Report

REFERENCE: Contract Number DAAK80-81-C-0175 (A-3061), Data Base Processing Development Plan for SIGMA.

Dear Mr. Derner:

This is a second in a series of reports addressing the status of and plans for the reference contract. This report covers the period October 1 - 31, 1981.

STATUS

The work indicated was conducted using the reporting period.

1. A meeting was conducted on October 29 - 30, 1981 with OPTADS personnel to present the status of the project. OPTADS personnel emphasized the requirement to deliver some DBMS capability to the field in the June 1982 time-period. A key event identified at this meeting was the ASARC III decision point (January - February 1983). The TCS will be evaluated as part of the Maneuver Control (MC) System at that time.

2. In investigating the TCS, Data General and Rolm were contacted to determine the capability of the host machine. It was apparent from these meetings that a full DBMS system was more viable under the ROLM MSE/14 (S-140) micro-processor with an Advanced Operating System (AOS). Rolm is presently defining the character instruction set which, when added in the Fall of 1982, will allow for the running of INFOS II, a Data General developed DBMS, and potentially other DBMS(s). This provides for a option with growth to support long-term MC requirements. However, the immediate solution is to select a commercially available DBMS and marry it to the existing Rolm 1666 (minus the floating point capability) and the Singer-Librascope modified Real Time Operating System (RTOS).
3. In determining the availability of DBMS; information is being collected on systems which are compatible with Data General Nova and Eclipse series machines. Information was received from approximately ten developers of DBMS and two government research organizations (DARPA and Army Institute for Research in Management Information and Computer Science). To date, we have not identified a manufacturer which has developed a DBMS for the 1666 using RTOS. However, are some commercially available DBMS(s) on the 1666 using the Real-Time Disk Operating System (RDOS) and AOS.

4. The initial effort to determine the information needs for the June 1982 time period focused on the Commanders Report and the records needed to generate this periodic summary. Individual unit records run from 350 to 600 characters depending on the design approach. Based on this information, a large data base at division is not anticipated.

PLAN

The following will be conducted during the next report period.

1. Meet with Singer-Librascope personnel to discuss the changes they have made to RTOS and changes anticipated in the future.

2. Review OS documentation to determine the effect of the RTOS changes.

3. Continue to call approximately fifty (50) DBMS manufacturers to determine the availability of a system to meet the June 1982 needs.

4. Continue to investigate approaches by which the user will input and output data to the DBMS.

PROBLEM AREA

Documentation concerning the Singer-Librascope modified RTOS and the rationale for the changes has been difficult to obtain; and as yet is not understood. Efforts being made in the next period will reduce this problem. Understanding of the existing OS is important to the task of recommending a near-term DBMS.
FUNDING STATUS

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Sincerely,

Edward J. Shanahan, Jr.
Project Director,
Command and Control Programs
Electronics & Computer Systems
Laboratory

Approved:

H. Bennett Teates,
Head,
Command and Control Programs
Electronics & Computer Systems
Laboratory

EJS/HBT:dar
Mr. Robert Derner  
Office of the Project Manager, OPTADS  
U.S. Army Communications - Electronics Command  
Fort Monmouth, New Jersey 07703  
Attention: DRCPM-OTD-TM

SUBJECT: Deliverable Number 3, November Monthly Status and Cost Report

REFERENCE: Contract Number DAAK 80-81-C-1075 (A-3061), Data Base Processing Development Plan for the Maneuver Control System (MCS)

Dear Mr. Derner:

This is the third in a series of reports addressing the status of and plans for the reference contract. This report covers the period November 1-30, 1981.

STATUS

The work indicated was conducted during the reporting period.

1. A meeting with Singer-Librascope personnel was conducted by Mr. H. Bennett Teates on November 3 to discuss the operating system used in the Tactical Computer System (TCS). Mr. Harry Hanson, the author of the current operating system, was not present at the meeting. Subsequent telephone conversations with Mr. Hanson have been helpful in our understanding of the modifications made to the operating system by Singer-Librascope. However, complete documentation, which Mr. Hanson indicated would be completed and sent to us, has not yet arrived.

2. Fifty eight vendors were called or contacted to determine the availability of an "off-the-shelf" data base management systems (DBMS) to meet the initial needs of the MCS. Eight DBMSs were selected for evaluation using the criteria of: cost; core requirements; number of users of the system; use of Fortran in writing the DBMS; amount of assembly language used; operating system interface; compatibility with a Rolm/Data General computer; availability of a query language; and availability of source code. Three DBMSs were selected for further investigation: Relate (Radian Corporation), SEED (International Data Base), and DNA-4 (Exact Systems).
PLAN

The following will be conducted during the next report period.

1. Meet with officials of Radian Corporation, International Data Base and Exact Systems to receive demonstrations/briefings concerning their respective DBMSs. Selection of a DBMS will be made after these meetings.

2. Initiate investigation into the feasibility of providing a DBMS for the Tactical Computer Terminal.

3. Investigate the manner by which the MCS DBMS will grow from the initial capability to the objective system.

FUNDING STATUS

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Sincerely,

Edward J. Pan'ahan, Jr.,
Project Director
Command and Control Programs
Electronics and Computer Systems Laboratory

Approved:

H. Bennett Teates,
Head, Command and Control Programs
Electronics and Computer Systems Laboratory

EJS/HBT:dar
Mr. Robert Derner  
Office of the Project Manager, OPTADS  
U.S. Army Communications - Electronics Command  
Fort Monmouth, New Jersey 07703  

Attention: DRCPM-OTD-TM  

SUBJECT: Deliverable Number 4, December Monthly Status and Cost Report  

REFERENCE: Contract Number DAAK80-81-C-0175 (A-3061) Data Base Processing Development Plan for the Maneuver Control System (MCS)  

Dear Mr. Derner:  

This is the fourth in a series of reports addressing the status of and plans for the reference contract. This report covers the period December 1-31, 1981.  

STATUS  

The work indicated was conducted during the reporting period.  

1. On December 10-11, Mssrs. Teates and Shanahan with government personnel attended briefings presented by the two remaining corporations who may meet the DBMS requirements. Exact Systems gave their briefing on DNA-4 at the Data General office in New York City. Radian Corporation presented their DBMS (Relate) at Fort Monmouth. Both corporations have strengths and weaknesses. Exact Systems has an assembly language-based DBMS which appears to meet the initial requirements for MCS. However, the organization may not have the size or structure to support future system development. Radian Corporation has organizational and fiscal support for the long term, but their FORTRAN based DBMS is not currently as refined as DNA-4. After joint Georgia Tech and government consultation, it was decided to offer both corporations the opportunity to devote one month to interface their DBMS with the Tactical Computer System (TCS).  

2. On December 14 - 16, Mr. Teates joined government personnel and representatives of Exact Systems and Radian Corporation on a visit to Singer Librascope in California. The purpose of the visit was to allow the two contractors to inspect the features of the operating system (OS) of the TCS. The OS interface with the DBMS
key to meeting the initial requirement of a June 1982 fielding of a DBMS with the capability of producing a Commanders' Report and of responding to queries based on data elements which comprise this report. After these meetings, both contractors accepted the challenge of interfacing their DBMS with the TCS by January 20, 1982.

3. An initial draft of the evolutionary process of developing a MCS DBMS was completed during the report period. The draft addresses increases of technical and operational capabilities in six semesters through December 1984. This draft is currently being reviewed within Georgia Tech.

PLAN

The following will be conducted during the next report period.

1. On January 21-22, review the work of both Exact Systems and Radian Corporation in interfacing their DBMS to the TCS. This review will be conducted in California.

2. On January 25-26, meet with government personnel in Fort Monmouth to select the appropriate DBMS.

3. Continue to revise the draft of the evolutionary process plan.

4. Prepare the draft of the final report.

PROBLEM AREA

No major problem areas were identified.
Monthly Status and Cost Report  
January 8, 1982  
Page # 3  

FUNDING STATUS  

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Sincerely,  

Edward J. Shanahan, Jr.,  
Project Director,  
Command & Control Programs  
Electronics & Computer Systems Laboratory  

Approved:  

H. Bennett Teates,  
Head, Command & Control Programs  
Electronics & Computer Systems Laboratory  

EJS/HBT:dar
Mr. Robert Derner  
Office of the Project Manager, OPTADS  
U.S. Army Communications-Electronics Command  
Fort Monmouth, New Jersey 07703  

ATTENTION: DRCPM-OTD-TM  

SUBJECT: Deliverable Number 6, January Monthly Status and Cost Report  

REFERENCE: Contract Number DAAK80-81-C-0175 (A-3061) Data Base Processing  
Development Plan for the Maneuver Control System (MCS)  

Dear Mr. Derner:

This is the last in a series of reports addressing the status of and plans  
for the reference contract. This report covers the period January 1 - 31,  
1982.

STATUS

The work indicated was conducted during the reporting period.

1. On January 21-22, 1982, Mr. Teates participated in a review of the  
vendor's (Exact Systems and Radian Corporation) demonstrations of their  
capability to interface their DBMS with the TCS. Both companies were  
successful: Exact easily fit within the core requirements of the TCS and  
provided a menu-driven report generator; Radian met the goal of sizing  
their system in the TCS environment but were limited in their operations  
because of the lack of a GFE FORTRAN run-time library. They did, however,  
display an "ad hoc" retrieval capability which is not available in the  
current version of DNA-4 (Exact).

2. On January 25-26, 1982, Mssrs. Teates and Shanahan attended a meeting at  
Fort Monmouth to discuss the vendor's demonstration and to determine  
future courses of action towards establishing an initial DBMS in June  
1982. It was decided that both companies would submit proposals to develop  
the initial capabilities. (Subsequently, the government decided to fund  
both companies in this effort). At this meeting, GIT was tasked to  
develop a data base demonstration/test package to assure that a useful  
capability was established. The impact of this request was an extension  
to the current project (with no additional funding) and a delay in  
producing the final report.
PLAN

The following will be conducted.

1. Develop a data base demonstration/test package which will assure the government that the selected DBMS is acceptable and that will display the resulting capabilities to potential users.

2. Continue to work on the draft of the final report.

3. Establish a (no-cost) extension of the current contract to April 30, 1982 and a new submission date for the draft final report of March 9, 1982.

PROBLEM AREA

No problem areas were identified.

FUNDING STATUS

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Sincerely,

Edward J. Shanahan, Jr.
Project Director
Command and Control Programs
Electronics & Computer Systems Laboratory

Approved:

H. Bennett Teates,
Head, Command and Control Programs
Electronics & Computer Systems Laboratory

EJS/HBT:dar
March 9, 1982

Mr. Robert Derner  
Office of the Project Manager, OPTADS  
U.S. Army Communications-Electronics Command  
Fort Monmouth, New Jersey 07703  

ATTENTION: DRCPM-OTD-TM  

SUBJECT: Deliverable Number 8, February Monthly Status and Cost Report  

REFERENCE: Contract Number DAAK80-81-C-0175 (A-3061) Data Base Processing Development Plan for the Maneuver Control System (MCS)  

Dear Mr. Derner:

This is the last in a series of reports addressing the status of and plans for the reference contract. This report covers the period February 1 - 28, 1982.

STATUS

The work indicated was conducted during the reporting period.

1. A draft data base demonstration/test package was developed. The packages gives the government the ability to determine the suitability of the data base management system to provide the services of "rolling-up" the commander's report and of ad hoc queries using a menu-driven approach. In addition, the test examines system responses to abnormal conditions.

2. Work continued on the draft of the final report. This effort was delayed as priority was given to the demonstration/test package. Estimated date of completion of the draft is March 12, 1982.

3. A no-cost extension of the contract was initiated to establish a completion date of April 30, 1982.

PLAN

The following will be conducted.

AN EQUAL EMPLOYMENT/EDUCATION OPPORTUNITY INSTITUTION
1. Continue to assist in the establishment of a data base demonstration/test package. Coordination of this effort will be maintained with the Software Development Support Center at Fort Leavenworth.

2. Complete the draft final report.

PROBLEM AREA

No problem areas were identified.

FUNDING STATUS

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Sincerely,

Edward J. Shanahan, Jr.,
Project Director
Command and Control Branch
Electronics & Computer Systems Laboratory

Approved:

H. Bennett Teates,
Head, Command and Control Branch
Electronics & Computer Systems Laboratory

EJS/HBT: dar
Mr. Robert Derner  
Office of the Project Manager, OPTADS  
U.S. Army Communications-Electronics Command  
Fort Monmouth, New Jersey  07703

ATTENTION:  DRCPM-OTD-TM

SUBJECT: Deliverable Number 8, March Monthly Status and Cost Report

REFERENCE: Contract Number DAAA50-81-0175 (A-3061) Data Base Processing Development Plan for the Maneuver Control System (MCS)

Dear Mr. Derner:

This is the last in a series of reports addressing the status of and plans for the referenced contract. This report covers the period March 1-31, 1982.

STATUS

The work indicated was conducted during the reporting period.

1. Continued coordination was maintained with the Software Development Support Center at Fort Leavenworth concerning the data base demonstration/test package.

2. The draft final report was completed and forwarded to Fort Monmouth for review by the government.

PLAN

After comments are returned from the government, the final report will be published and distributed.

PROBLEM AREAS

No problem areas were identified.
Mr. Robert Derner  
Progress Report Letter  
Page # 2

**FUNDING STATUS**

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Sincerely,

Edward J. Shanahan, Jr.
Command and Control Programs
Electronics & Computer Systems Laboratory

Approved:

H. Bennett Teates  
Head, Command and Control Programs  
Electronics & Computer Systems Laboratory

EJS/HBT: nr
DATA BASE PROCESSING DEVELOPMENT PLAN
FOR
THE INITIAL MANEUVER CONTROL SYSTEM
Technical Report # 1
GIT/EES Project Number A-3061
Under Contract Number DAAK80-81-C-0175
DATA BASE PROCESSING DEVELOPMENT PLAN
FOR
THE INITIAL MANEUVER CONTROL SYSTEM

Technical Report # 1
GIT/EES Project Number A-3061
Under Contract Number DAAK80-81-C-0175

May 1982

Prepared for:
DEPARTMENT OF THE ARMY
United States Army Communications
Electronics Command
Fort Monmouth, New Jersey

Prepared by:
Edward J. Shanahan, Jr.
H. Bennett Teates
Command and Control Programs Branch
Electronics and Computer Systems Laboratory
Engineering Experiment Station
GEORGIA INSTITUTE OF TECHNOLOGY
Atlanta, Georgia 30332
FORWARD

The Maneuver Control System (MCS) augments the Operations Officer's (G-3/S-3) ability to effectively employ battlefield resources by providing a capability to assist the battlefield commander in planning, deciding and executing. Recognizing the complexity of command and control system development, the Project Manager, Operational Tactical Data Systems, has implemented a developmental approach of evolutionary growth that directly incorporates user feedback, and has placed a baseline MCS into realistic exercises and day-to-day operations in Europe.

The Georgia Institute of Technology's Engineering Experiment Station has been and is providing "third party" evaluation and technical assistance to the office of the Project Manager. This report, the first in a series, summarizes the results of the technical assistance provided in the selection of an initial data base management system capability for the Tactical Computer System - one element of the MCS. This report pertains to the time period from November 1981 through April 1982 and "sets the stage" for subsequent reports that will address work relevant to technical tasks to be assigned in the future.
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**ANNEX**

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- **2-1** DBMS STRUCTURE: Types and Characteristics
- **3-1** DBMS Comparison Chart
- **3-2** Comparison Chart
SECTION I

INTRODUCTION
1.0 INTRODUCTION

1.1 Purpose

The purpose of this report is to document the work performed by Georgia Institute of Technology (GIT) personnel in the development of an approach for the establishment of a Data Base Management System (DBMS) for the Army's Maneuver Control System (MCS) and for the evolutionary growth of the system using tactical computer systems, the Tactical Computer System (TCS) and the Tactical Computer Terminal (TCT).

1.2 Background

The Project Manager (PM) of the Operational Tactical Data Systems (OPTADS), since 1979, has undertaken a two-pronged acquisition approach for the development of the MCS, a key element of the tactical Army Command, Control Subordinate System (CCS\(^2\)). (Figure 1-1 displays the five tactical battlefield functions—(maneuver control, fire support, air defense, intelligence/electronic warfare, and combat service support)—which comprise CCS\(^2\)). The two approaches are commonly known as the Top-Down and Bottom-Up Approach. The Top-Down Approach is a long-term development cycle, starting with a functional specification and a competitive solicitation to industry for design and development. This approach has been initiated and proposals are currently being evaluated.

The Bottom-Up Approach is a parallel effort in conjunction with the long-term development. In this approach, the PM has deployed two types of computer systems to the field for use in realistic exercises and day-to-day operations. These computers, the TCS and the TCT, have progressed in the acquisition cycle to where they will be considered for full production and deployment by an Army System Acquisition Review Council (ASARC) in early 1983.
FIGURE 1-1 COMMAND, CONTROL SUBORDINATE SYSTEM (CCS²).
The TCS and TCT contain computers, peripherals and communications interfaces capable of meeting additional requirements appropriate to the needs of maneuver control. In recognition of these inherent capabilities, the PM has been evolving, in step-wise progression, the TCS and TCT to exploit the capabilities of the computer system to meet the needs of the ultimate maneuver control system. In fact, the baseline of the Top-Down and the Bottom-Up acquisition development is to employ the TCS and TCT as the initial capability of the MCS design. The project reported in this document addresses the evolutionary development of a data-base management capability as part of the Bottom-Up Approach.

1.3 The Project Assignment as Stated and as Implemented

Initially the project was composed of three tasks. Stated briefly, these tasks were:

1. Definition of the Data Base Requirements (i.e., obtain a broad perspective on the various factors that would influence the content, structure and effectiveness of the data base management capability.)

2. Technology Infusion (i.e., gain a perspective on the hardware and software needs and capabilities to support the data requirements.)

3. Analysis and Plan (i.e., analyze the information collected from Tasks 1 and 2, and develop a plan for the evolutionary growth of a data base processing capability.)

As these tasks were being initiated, early discussion with Program Manager (PM) personnel resulted in emphasis being placed upon the identification of a commercially available DBMS which could be adapted to the TCS and be fielded in Europe by June 1982. This slight redirection of the tasks was prompted by the recognition of the need to present a Maneuver Control System (MCS) supported by a DBMS at the Army System Acquisition Review Council (ASARC) meeting scheduled for January 1983. It is the PM's view that ASARC success is dependent upon the TCS being not only the effective "message handler" that it
has proved to be, but also a data processing and information retrieval system. Hence, the three initial tasks took on the urgency of meeting only a limited set of the criteria that would have been used for the initial, more general systems analysis. For example:

- Instead of considering all the elements of information retrieval required to meet the MCS Required Operating Capability (ROC), emphasis was placed upon meeting the information retrieval needs for Friendly Situation (FRENSIT) information and to produce and "roll-up" from battalion to corps, the Commander's Report (see Figure 1-2). A detailed explanation of the Commander's Report is provided in paragraph 3.2.

- Instead of considering both TCS and TCT hardware and software, emphasis was placed upon matching off-the-shelf DBMSs to the TCS and its Operating System (OS).

- Instead of a long-term DBMS, data set, OS, and hardware integration plan--immediate emphasis was placed upon short-term comparative competition of viable DBMS contractors and upon coordinating the efforts of the various Army agencies and contractors.

However, as discussed in this report, much of the substance of the original three tasks has been completed and a logical, evolutionary path is provided to develop the DBMS capability in MCS from an initial capability to the objective system.
FIGURE 1-2 COMMANDER’S REPORT FORMAT.
SECTION II

INVESTIGATION
SECTION II

2.0 INVESTIGATION

2.1 Introduction

Owing to the change in project emphasis discussed in Section 1, the investigative phase of the project took on both a general and a specific aspect. The general aspect dealt with the original tasking which was to take into account considerations of future upgrades and changes. The specific aspect dealt with the tasking as changed, based upon guidance given by PM personnel to concentrate on the immediate need to establish a DBMS capability. As it turned out, there were several instances in which the two aspects converged onto a single approach. This section presents a discussion of the considerations involved in meeting both the general and specific aspects. Considerations investigated and discussed below are DBMS, hardware, and software.

2.2 Major Considerations

2.2.1 Data Base Management System Considerations

A command and control system is essentially a support element of the commander, the decisionmaker. It is assumed that better decisions are made if the commander has all the information available required to make the decision. Computers and their associated memory have long been recognized as tools which can store information far too voluminous for the commander to retain without many aids, and software has been developed over the past decade that responds to decisionmaker's queries, both routine and ad hoc. The software that collectively manages the interface with the user, with applications programs, with the operating system, and with physical storage and retrieval of data is
known as a Data Base Management System (DBMS). Four prime considerations in the design of a DBMS are: complexity of the data base, inquiry capability, response time, and the independence of logical structure and physical storage. A fifth (and key) consideration for military use is ease of using the data entities and understanding their relationships. Basically, three types of DBMS structures have been developed which take into account these considerations. Table 2-1 summarizes the three types (hierarchical/network, inverted, and relational) and characteristics of each.

Based upon an accumulation of input (see Annex A) from organizations and people who have built and worked with DBMSs and the currently commercially available relational DBMS packages, the relational DBMS structure was tentatively chosen as the one most appropriate for the evolution of the requisite TCS data storage and retrieval capability.

The perceived advantages of the relational-like DBMS are:

1. The relational data model shields the user from data formats, access methods and the complexity of storage structures.

2. It supports a high-level, non-procedural manipulation and query language, resulting in reduction of user workload.

3. The storage and data structures are very simple, all data are represented in the form of two-dimensional tables.

4. Access paths do not have to be predefined. A number of powerful operators are supported in a relational model, e.g., select, project, join, etc. for data retrieval.

5. The relational model has fast response to ad hoc queries which often are a high-percentage of queries.

6. The relational model supports expected advantages in associative storage devices.
DBMS STRUCTURE: TYPES AND CHARACTERISTICS

<table>
<thead>
<tr>
<th>TYPE</th>
<th>MAJOR CHARACTERISTICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hierarchical/Network</td>
<td>1. Owner/member record relationship</td>
</tr>
<tr>
<td></td>
<td>2. Records linked via point scheme</td>
</tr>
<tr>
<td></td>
<td>3. Access via key records</td>
</tr>
<tr>
<td></td>
<td>4. Searches via chain/point connectors</td>
</tr>
<tr>
<td></td>
<td>5. Records stored logically in pages</td>
</tr>
<tr>
<td>Inverted</td>
<td>1. Records of one type stored in each file</td>
</tr>
<tr>
<td></td>
<td>2. Records related via key file</td>
</tr>
<tr>
<td></td>
<td>3. Access via an index to the key file, then to the record</td>
</tr>
<tr>
<td></td>
<td>4. Searches made easy because the value of each field in the key fields must be in the key file</td>
</tr>
<tr>
<td></td>
<td>5. Records stored serially and keys refer to actual disk locations</td>
</tr>
<tr>
<td>Relational</td>
<td>1. Records stored in tables</td>
</tr>
<tr>
<td></td>
<td>2. Records are created to meet specific user needs</td>
</tr>
<tr>
<td></td>
<td>3. Access via an index to table</td>
</tr>
<tr>
<td></td>
<td>4. Searches made easy because the key is the table identifier</td>
</tr>
<tr>
<td></td>
<td>5. Records are created dynamically, attached to a table and stored via an indexing scheme</td>
</tr>
</tbody>
</table>


TABLE 2-1

10
Disadvantages are:

1. Potential for slow response time to queries especially if there is a need for extensive union and intersection across tables.

2. Requirement for user to be sophisticated in his understanding of the data base.

2.2.2 Hardware Considerations

Hardware considerations were investigated to the extent to which they affected the operating system and the interface to a DBMS. In presenting hardware discussion, it is necessary to first understand the basic requirements against which TCS development has been governed to date, namely:

1. A fully militarized system that would be used in tracked vehicles (M577) operable by soldier (not computer operators);

2. A set of defined, unbundled interfaces that would allow for future exploitation of additional modules (processors and peripherals); and

3. Compatibility with present and planned communication systems.

Because of these considerations, the TCS was designed to focus on communication interrupts as the highest priority.

The central processor of the TCS is a ROLM 1666. The ROLM family of computers are fully militarized and are repackaged Data General computers with only minor modifications. The TCS input/output (I/O) hardware provides the capability to interface with the KG-31 (a device which provides for secure transmissions), the GYK-12 computer, undefined future TACFIRE (GYK-12) peripherals, standard ROLM peripherals, a memory (program) loading module, and the basic TCS peripherals (which ostensibly includes up to 64 channels of high
speed (32K baud) digital communications). The military interfaces are specialized and require different voltages, formats (serial/parallel), and data rates. The system interfaces between the control processor and the I/O hardware is non-standard and, therefore, not compatible with off-the-shelf modules.

In order to minimize the number of cables and "packages" within the system, the TCS Data I/O Module (DIOM) provides a single interface package between the CPU I/O bus and all required peripherals (in exactly the same manner a ROLM or Data General I/O expansion chassis is used). In addition, each interface transfers data via Direct Memory Access (DMA) so the CPU I/O loading is reduced to initiating a data transfer, and responding to the DIOM generated interrupt when the data transfer is complete. All data rate, format, and voltage level conversions are performed by the individual interfaces within the DIOM.

The DIOM also contains the Voice Controller and Voice Multiplexer, as well as power distribution for all TCS equipment and peripherals, BITE indicator, and over-under primary voltage servicing. In addition, controls and indicators are provided including BITE, power and purge.

2.2.2.1 Hardware Upgrading

The ROLM 1666 is capable of addressing a larger amount of random access memory (RAM) than packaged in the current configuration. It is currently planned as part of the upgrade from the 1666 to 1666B to increase memory capability. Additionally, it is planned to provide a floppy disk (auxiliary memory) capability and eventually to add bubble memory storage. The Advanced Development/Engineering Development (AD/ED) version of these three upgrades is planned to occur in CY1982, but only the floppy disk was considered in this effort for the initial DBMS capability.
2.2.2.2 Hardware Evolution

The establishment and evolution of the DBMS capability in the Maneuver Control System places new requirements on the TCS, the prime computer device in the system. Designed with communications interrupts as its prime consideration, the orientation of the TCS will change towards increased priorities to auxiliary storage devices as additional services are provided by the DBMS. The PM should be aware of the difficulties encountered in moving to any new processor. In addition to the physical problems of substituting hardware, the effect of this change on the OS (and potentially on applications software) is substantive. Nevertheless, this change may be required if field use of the system indicates a need for increased priorities to storage devices and more computational capability.

The MCS developer is committed to implementing the Army's Military Computer Family when it is available. The first evolution of hardware of the Army's Military Computer Family (MCF) is currently being developed as MIL-STD-1862. It has been dictated by the Army Staff that programs employing embedded computers are to utilize the MCF. Current plans and progress on the development of the MCF indicate that it will be available by the 1984-85 time-frame. This fits easily into the preplanned product improvement philosophy of the new DoD Directive 5000.1.

If the MCF does not meet MCS time requirements, other alternatives should be investigated. Although the 1666B is highly capable, it does not have the capability of the ROLM MSE-14. This latter processor is a militarized version of the successful Data General Eclipse S-140. The S-140 is widely used in both military and commercial applications and has a broad base of software support. Several of the larger, more well-known DBMS packages (e.g., ORACLE and IDMS) have been or currently are being placed on the Eclipse. From a hardware standpoint, the 1666B can be converted to an MSE-14 by changing the CPU cards, which contain the MSE instruction set microcode. This alternative also takes advantage of the preplanned product improvement philosophy.
Another alternative is the establishment of a dual processor capability, e.g., two 1666B processors, a combination of one 1666B and one MSE-14, etc. One processor would be oriented towards communications interrupts and control of message flow; the other to data base functions. Adoption of any of these approaches, although fitting within the preplanned product improvement philosophy, could involve major changes to the TCS depending on implementation and probably result in new DT&E requirements for field acceptance of the computer system. On the other hand, if for example, two 1666B processors were used, logistical support functions (e.g., maintenance, spares, training, etc.) already put into effect to support the TCS could be capitalized upon.

In sum, the possibility exists for the Government to enhance the TCS hardware based upon feedback from field exercises and new requirements. Three alternative hardware-evolution paths are presented as potential solutions to the problem. While it is recognized that the changing of a processor is a major step with system and software (both OS and applications) ramifications, this action may be needed as demands of the data base are recognized.

2.2.3 Software Considerations

Software, particularly the Operating System (OS), has been specially developed for the TCS. This development was necessary for three reasons. First, the peripherals and I/O hardware were non-standard and required capabilities which were not offered by the standard ROLM-supported operating systems. Second, the TCS had no auxiliary (i.e., disk) memory as required by the more capable of the ROLM operating systems (e.g., RMX-RDOS). Third, the ROLM operating systems for the 1666 do not provide the file security required of the TCS.

As a DBMS must interact with the operating system, the specially designed OS for the TCS became a major consideration in the selection of a commercially available package for the initial DBMS capability.
2.2.3.1 Software Upgrades/Evolution

The current TCS operating system (known herein as the TCS operating system 2 (OS2)) is to be upgraded to include the floppy disk and bubble memory hardware planned for CY82. As these devices are added and as the hardware evolution alternatives (discussed in paragraph 2.2.2) take form, the issues of using "off-the-shelf" operating systems (e.g., RMX-RDOS), enhancing the Singer OS or adopting the MCF/Ada results become germane to the evolution of the TCS and the development of a more capable DBMS.

Alternatives and their advantages and disadvantages are discussed briefly below.

2.2.3.1.1 Enhance the TCS OS2

The TCS OS2 is unique and supportable by only Singer, although support by Army personnel is planned. This OS was implemented as an initial capability with plans to enhance it based upon lessons learned from field use. For example, it is known that adding secondary memory, a DBMS and other applications software (e.g., models for planning operations) will require this OS to be enhanced. Plans for enhancement need to include considerations of efficiency and compatibility with the growth of DBMS capability.

2.2.3.1.2 Modify and Install ROLM RMX-RDOS

The ROLM RMX-RDOS, if adopted, would require the modification of current applications packages and I/O driver routines, TCS communications requirements would have to be reduced, or RMX-RDOS modifications would have to be made to allocate additional DMA ports and additional device codes beyond the maximum of sixty-four. On the positive side, RMX-RDOS is the underlying OS in such military programs as the Navy's "Outlaw Shark" and the Army's Automatic Ground Transportable Emitter Location/Identification System, as well as a number of commercially available DBMSs (e.g., DNA-4, RELATE, SUPER-English, CREATE, and RAPPORT). Although it would be necessary to modify the software to account
for the TCS configuration, the advantage of using RMX-RDOS in a "near-standard" configuration is larger base of support (i.e., language, maintenance, applications and programmer experience). This advantage implies reduction of costs in future software development and potential reduction in life cycle costs of software support.

2.2.3.1.3 Adopt Ada for MCF

The Army is developing the MCF devices and a series of Ada compilers. As with the MCF hardware, Department of Army Staff has directed that Ada be used in future systems and system upgrades. Ada compilers are being developed for the ROLM 1666 by the Army (CECOM) that will inherently contain the ability to design into applications software normal OS functions. As this evolution is completed, the applications programs, utilities, and DBMS packages will have to be modified. The advantage of this change is commonality of hardware and software language and cost-effective life cycle support of Army embedded computer systems.

2.2.3.1.4 Adopt an Ada-Based Operating System for ROLM Hardware

The adoption of Ada for the ROLM 1666 is a subset of the approach just discussed and has two alternatives. First, OPTADS is supporting the development of an Ada operating system for the TCS per se. Second, the Army is supporting the development of an Ada compiler for a "bare" ROLM 1666 which would permit the development of an OS to support TCS applications. Either of these approaches has the disadvantage of having to rewrite existing TCS software. The advantage is the potential gain in cost-effective life cycle support because of the assumed larger base of users and existing logistical chain.
2.2.3.1.5 Modify and Install ARTS

As in the case of hardware considerations, it is worthy to note a possible "fall-back" position should the MCF Program falter and a need for greater processing capability is demonstrated. This "fall-back" is to use the ROLM MSE-14 and the powerful and commercially supportable operating system, the Advanced Operating System (AOS). It is purported by ROLM that it is developing an Ada compiler for the MSE-14 that would run under the AOS or its real-time derivative, Advanced Real-time System (ARTS). Furthermore, it is known that commercially available DBMS packages (e.g., ORACLE) are being or have been developed for the AOS.

2.3 Related Considerations

Other considerations that must be kept in mind in the selection, implementation and evolution of the DBMS are:

1. Multi-user requirement.

   It is a requirement of the MCS that more than one user be allowed to interact with the database. Indeed, the requirement to date has been for the TCS to support and to communicate with a number of remote users concurrently. Hence, in looking for a DBMS package, it is appropriate to look for one that allows multi-user interaction.

2. TCT DBMS.

   The Tactical Computer Terminal (TCT) is being employed to serve as the more mobile element of the MCS. The TCT employs a MC6800 as its central processor and, thus, generates a new set of software and DBMS requirements. These requirements need further study, especially as the Government is considering upgrading to the MC68000 processor.
SECTION III

SELECTION OF A DBMS TO MEET INITIAL CAPABILITY
SECTION III

3.0 SELECTION OF A DBMS TO MEET INITIAL CAPABILITY

3.1 General

Once the technical understanding of the data base management systems, the TCS and TCT hardware, and the unique operating system of the TCS was achieved, the effort focused on meeting the initial capability for MCS. Because of the desire to field the DBMS in Europe by June 1982, a limited capability was selected by the government. This capability can be summarized as follows:

- The roll-up from brigade to division levels of the Commander's Report (CDRREP) and FRENSIT capabilities will be the initial application.
- The TCS (with no major changes) will be the target machine.
- The ability to demonstrate utility of data handling will be more important than the technical excellence of the DBMS.

3.2 Commander's Report

The Commander's Report (CDRREP) is a message which is sent to the next higher echelon outlining the situation and resources of the unit and its immediate subordinates. Figure 1-2 indicates the format of the message and its information content. The requirement is to automate the development of the message so that much of the information will be compiled from reports submitted by lower echelons. Specifically, the information which the computer will calculate from subordinate reports is the mix of balanced, mechanized, armor, cavalry, infantry, airborne and air mobile (indicated by B, M, A, C, I, AB, AM on the form) units and the status of tanks, Tow and Dragons, the latter two being anti-tank weapon systems. This information will be "rolled up" by computing totals and tasks organizations upward with each level of reporting.
3.3 FRENSIT File Query

The DBMS must to be capable of storing and retrieving any of the entries (i.e., fields) contained in the CDRREP. Storing of these data must be automatic and retrieval was to be operator-assisted by selection of query types from a DBMS-generated menu of FRENSIT file queries. The FRENSIT file queries will take the form of:

- Equal, e.g., for unit identification, mission, etc.
- Greater than, e.g., for total resources, battle resources, communications, etc.
- Equal to and greater than.
- Less than.
- Equal to and less than.

The DBMS will have the capability to query both a numeric and color coded attribute. An example of a query with numeric attributes is to search for and print a list of units which have less than forty-two tanks. An example of a query with a color code attribute is to search for and print a list of units which have less than a green condition for their communications capability.

3.4 Determination of Suitable DBMSs

3.4.1 Survey of Available DBMSs

GIT initiated a survey of the DBMS market to determine the availability of a commercial, off-the-shelf package which could meet the requirements of the initial system. Annex A is a summary of information received from the fifty-eight organizations contacted via telephone or visits. (More detailed information concerning these contacts is on file at GIT.) Criteria were established in conjunction with the government to assist in the selection.
Table 3-1 displays the criteria in matrix format and reflects the information gathered concerning eight companies which had DBMSs with what appeared to be the greatest potential to meet the MCS application in the time frame required. Based on these criteria, the number of organizations was reduced to:

- Radian Corporation and its DBMS, RELATE
- Exact Systems and its DBMS, DNA-4
- International Data Base and its DBMS, SEED

3.4.2 Selection Process

Government personnel visited International Data Base personnel to determine their interest in meeting the requirement. Because of their non-familiarity with the TCS or Data General machines and a corporate-level decision that their interest resides with Digital Equipment Corporation (DEC) computers, International Data Base elected not to participate in the project.

GIT and government personnel visited with representatives from Radian Corporation and Exact Systems to derive more information concerning their respective DBMSs and to assess their potential to support the evolution of the DBMS within the MCS program. Table 3-2 reflects the result of that visit.

Both vendors have strengths and weakness. Radian Corporation has a relational DBMS written in a high-order language (FORTRAN) which supports easy maintainability in the out-years. Their corporate strength and organization is impressive when considering the evolution of the system. However, RELATE is currently established on only one site and is not immediately transferable to the Army application. In fact, there was some concern for the size of RELATE in the limited core memory of the TCS. In contrast, Exact’s DNA-4 is a menu-driven system, which easily meets the core sizing of the TCS and is readily transferable to the MCS’s initial needs. However, DNA-4 is written in macro-assembly code, which hinders long-term, government-provided maintenance. Further, the size of the Exact System Corporation (less than eight full-time employees) the approach (inverted sequential) of their DBMS, and their fiscal strength is a detriment to meeting the long-terms goals of the MCS program. In sum, Radian Corporation has short-term weaknesses and long-term strengths while Exact Systems has short-term strengths and long-term weaknesses.
<table>
<thead>
<tr>
<th>COMPANY</th>
<th>Interactive Tech</th>
<th>Radian Corp</th>
<th>Interim Database</th>
<th>Complete</th>
<th>Automated Quill</th>
<th>American Logic</th>
<th>Exact Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RDM</td>
<td>Relate</td>
<td>Seed</td>
<td>Create</td>
<td>Super English</td>
<td>Rapport</td>
<td>DNA-4</td>
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<tr>
<td>Cost</td>
<td>ND</td>
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<td>ND</td>
<td>$15K</td>
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<tr>
<td>Memory require-</td>
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<td>100K</td>
<td>32K</td>
<td>56K</td>
<td>ND</td>
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<tr>
<td>ments</td>
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<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>No. of users</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>Program Language</td>
<td>PASCAL</td>
<td>FORTRAN</td>
<td>FORTRAN</td>
<td>BASIC</td>
<td>ND</td>
<td>FORTRAN</td>
<td>Assembly</td>
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<tr>
<td>Rolm or Digital</td>
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<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>Query Language</td>
<td>No</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>ND</td>
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</tr>
<tr>
<td>Source Code Available</td>
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<td>Yes</td>
<td>ND</td>
<td>ND</td>
<td>Yes</td>
</tr>
</tbody>
</table>

ND = Not Determined.

**TABLE 3-1**

DBMS Comparison Chart
(This table reflects information as of November 1981 and should not be construed to reflect current capability of any DBMS.)
### COMPARISON CHART

<table>
<thead>
<tr>
<th>EXACT SYSTEMS</th>
<th>RADIANT CORPORATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Company:</strong></td>
<td><strong>Medium</strong></td>
</tr>
<tr>
<td>- Small</td>
<td>- Austin, TX based</td>
</tr>
<tr>
<td>- New York based</td>
<td>- Software division provides services, products, and system integration</td>
</tr>
<tr>
<td>- Data Base Applications</td>
<td>- <strong>Clients:</strong></td>
</tr>
<tr>
<td></td>
<td>- Environmental Protection Agency</td>
</tr>
<tr>
<td></td>
<td>- National Institute of Health</td>
</tr>
<tr>
<td></td>
<td>- Defense Mapping Agency</td>
</tr>
<tr>
<td><strong>Clients:</strong></td>
<td><strong>Market Applications:</strong></td>
</tr>
<tr>
<td>- Business</td>
<td>- Technical</td>
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<tr>
<td></td>
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<td><strong>Market Applications:</strong></td>
<td><strong>FORTRAN</strong></td>
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<td>- Inventory</td>
<td>- <strong>Features:</strong></td>
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<td>- Operations</td>
<td>- Query language</td>
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<td>- Accounting</td>
<td>- Polygon processor</td>
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<td>- Financial</td>
<td>- Report writer</td>
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<td><strong>DBMS:</strong></td>
<td><strong>Primary modules</strong></td>
</tr>
<tr>
<td>- Macro assembler</td>
<td>- <strong>Query</strong></td>
</tr>
<tr>
<td></td>
<td>- Report</td>
</tr>
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<td>- Inverted sequential</td>
<td>- Program language interface</td>
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<td>- Description</td>
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<td>- Load</td>
</tr>
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</tr>
<tr>
<td><strong>Supports all data models</strong></td>
<td><strong>Primary modules</strong></td>
</tr>
<tr>
<td></td>
<td>- Semi-portable(Limited by Macro assembly language)</td>
</tr>
<tr>
<td></td>
<td>- Portable (limited by OS dependent)</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Features:</strong></td>
<td><strong>Portable (limited by OS dependent)</strong></td>
</tr>
<tr>
<td>- Automatic documentation</td>
<td></td>
</tr>
<tr>
<td>- Language is screen generation</td>
<td></td>
</tr>
<tr>
<td>- Special tools</td>
<td></td>
</tr>
<tr>
<td>- Compatible word processor</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Primary modules:</strong></td>
<td><strong>Data General machines</strong></td>
</tr>
<tr>
<td>- Screen Generator</td>
<td></td>
</tr>
<tr>
<td>- Data Base Manager</td>
<td></td>
</tr>
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<td></td>
<td></td>
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</tr>
</tbody>
</table>

**TABLE 3-2**

23
3.4.3 Competition

To respond to this dilemma, both vendors were funded for a man-month of effort and given four weeks to interface their respective DBMSs with the unique operating system and core requirements of the TCS. On 21-22 January 1982, GIT personnel participated in a review of their efforts. Both were successful with some limitations: Radian operated within the core requirements, but could demonstrate only portions of their capabilities because of the unavailability of the government-furnished FORTRAN run-time-library. Exact Systems displayed the ability to produce a CDRREP, but needed further work with formatted FRENSIT queries.

3.4.4 Decision

Based on the success of both vendors, their continuing interests, their strengths and weaknesses, and the desires of the government to provide a data handling system in June 1982, it was decided by the government to fund both vendors to provide the initial capability. Milestones were established and proposals submitted.
SECTION IV

DATA BASE MANAGEMENT SYSTEM GROWTH
SECTION IV

4.0 DATA BASE MANAGEMENT SYSTEM GROWTH

4.1 General

The philosophy of the bottom-up approach to system development is the establishment of an initial (often modest) capability, the establishment of subsequent milestones, and evolution to an objective system. The key to this technique is the ability to receive meaningful feedback from the user community and to retain flexibility in refining subsequent milestones based on the return provided by the users. A "use-learn-develop" cycle is established with the understanding that the user in the field can best express his desires for final system capabilities after exercising the current version. The relationship of this cycle on the acquisition process is illustrated in Figure 4-1.

4.2 DBMS Evolution

The MCS Evolution Program is based on a modifiable semester approach, where capabilities are added every six months (June and December) for the out-years. Capabilities which will be added to the initial (June 1982) version of the DBMS are both technical and operational refinements. Priority is given to the operational, as visible results at the user level lead to increased support. GIT has developed a format which can be used to express the purpose of each milestone and the equipment necessary to support the field exercise. This format is shown in Figure 4-2. Each milestone is expressed as a stand-alone exercise in ANNEX B. However, an overview of the development through December 1984 is illustrated by Figure 4-3.
FIGURE 4-1 "USE = LEARN = DEVELOP" CYCLE.

Purpose: A description of the capability that will be added during the exercise.

Lessons Learned: A description of the diverse areas into which the exercise will provide insight. The questions asked fall under the general heading, "what will we learn?"

Environment: The environment in which the capability to be exercised will be used.

Users: The specific military operator or user. Generally the user is specified by position, and organizational level or military occupation speciality.

Assumptions: Specific limits or conditions forecast for the field exercise that further define the level of effort or have a bearing on cost determination.

Special Requirements: Forecast needs such as interoperability or other specific requirements that define the exercise boundaries.

FIGURE 4-2. FORMAT FOR FIELD EXERCISE DESCRIPTION
Capability of computer generation of Commander's Report and of Response to FRENSIT queries for single user.

ADD:
- Multiuser environment
- Definition of geographic area
- Security
- Other Info
- Enemy Info

ADD:
- Establishment of SRI
- Generation of alert message

ADD:
- Planning DB
- Redundant DB

Add:
- Refine SRI

Add:
- Distributed DB
- Redundant distributed DB

FIGURE 4-3 OVERVIEW OF FIELD EXERCISES.
4.3 Addition to TCS/TCT Capabilities

As the capabilities of the DBMS increase there are added requirements on the TCS/TCT in terms of processing strength, operating system, secondary storage and database sophistication. These requirements result from a desire for simplification in a complex (distributed) environment, large, non-centrally located data bases, and the anticipated desires of the users to generate "what if" questions in a volatile data base situation.

4.3.1 Processor/Operating System

The current processors and operating system are adequate to meet the initial needs of the DBMS for MCS. The present limitation of the operating system is its uniqueness and its small base of support. The limitation of the processor is its speed as the requirements for real-time communications, database requirements and number of users grow. As the MCS system grows on the battlefield, complexity is added in terms of services and of maintainability of the operating system. The logical upgrade appears to be a move to an Ada-based ROLM 1666 (see paragraph 2.2.3.1.4 for discussion). This upgrade would eliminate the unique operating system and provide a larger base of Army software support. Additionally, as the MCF devices become available, a smoother transition of processors is possible. (Should the MCF devices be delayed, the MSE-14 offers an attractive back-up alternative, particularly as it is reported that an Ada compiler and a sophisticated DBMS are being developed for this machine.)

Owing to the changing nature of the MCS requirements, a "front end-back end" hybrid approach is also a possibility. One concept is the use of the current TCS processor and OS to handle the communications requirements, (the front end) and to add a second processor (e.g., MCF, 1666B or MSE-14) with an ADA-derived US to handle the DBM and decision support requirements.

4.3.2 Secondary Storage

The use of floppy disks to store data and programs is satisfactory for the initial field exercise. As the amount of storage is not substantially
increased until the December 1983 exercise, no change is needed until that
date. However, because of the addition of planning and redundant data bases,
a substantial increase in storage can be anticipated to meet the requirements
of that exercise. Based on guidance provided by the government, bubble
memories with eight million byte capacity will be developed to meet the
requirements of the December 1983 exercise.

4.3.3 Data Base Management System

As the files become more volatile in MCS, considerations should be given
to approaches which best suit that environment. (A volatile file is one into
which new records are inserted, and possibly old ones deleted, at a high
rate.) The recommended approach towards meeting the initial requirement of
June 1982 is a menu-driven DBMS using an inverted sequential access technique
to search for data. With the addition of the SRI (Standing Request for
Information) requirement in June 1983 and intelligence information in June
1984, the situation changes to one more closely aligned to being volatile. In
addition, after a year of constant use, the needs of the users can be expected
to grow in terms of the sophistication of their requests. It is anticipated
that the trend will be towards more ad hoc queries as the user better
understands the contents of the data base and his capabilities to manipulate
the data. The DBMS should grow to meet these needs.

4.4 Technological Evolution

Figure 4-4 summarizes the considerations discussed in the preceding
paragraphs. It also provides the basis for the evolutionary development of
the DBMS capability for TCS. For example, in establishing a Pre-planned
Product Improvement Schedule, it is worth attempting to minimize the amount of
DT&E that would have to be redone. The figure indicates such a path by first
upgrading software, then hardware then software, then hardware; in effect
"leapfrogging" forward. In other words, the following path appears warranted:
FIGURE 4-4 SUMMARY OF TECHNICAL EVOLUTION.
A. Implement and pass DT&E with DBMS that runs on TCS OS2.

B. Enhance DBMS and TCS OS2 to meet user requirements (reports, speed; etc.) through December 1982.

C. Evolve to either Ada compiler being developed for TCS or to Ada compiler being developed for "bare" ROLM 1666.

D. Determine extent of changing MCS/TCS requirements and upgrade to MCF, the MSE-14, two 1666s (the front-end, back-end approach), or depending upon results of determination, remain with 1666.

E. Adopt Ada distributed DBMS capability to the MCS.
SECTION V

RECOMMENDATIONS
SECTION V

5.0 RECOMMENDATIONS

5.1 Recommendations Concerning the Establishment and Evolution of DBMSs

The following recommendations concerning the establishment and evolution of a DBMS for MCS are submitted.

A. Adopt the semester approach as reflected in Annex B as the guide for establishment and evolution of the DBMS for MCS.

B. Continue to support both vendors (Exact Systems and Radian Corporation) in their DBMS efforts until sufficient field feedback is obtained. Initiate an effort to establish criteria (e.g., multi-user, ad-hoc query, speed, cost) and thresholds to be met by the DBMS alternatives and to collect objective data in order to select a single DBMS vendor.

C. Anticipate growth of user needs with his experience and the evolution of MCS requirements in conjunction with MCF/Ada and begin the development of OSs, DBMSs applications and utilities to evolve in step with these developments.

D. Collect user-feedback and technical information and be prepared to adopt the development indicated in Section IV by:

1. Enhancing current DBMS/OS.
2. Using Ada compiler for TCS to change applications packages.
4. Upgrading to MCF hardware or its backup, MSE-14, if deemed appropriate.
5. Adopting from DARPA, or from the Army, an Ada distributed DBMS capability.

E. Continue to obtain user and technical requirements on the TCT in the DBMS arena.
ANNEX A

Companies Called for Information
Regarding DBMS
<table>
<thead>
<tr>
<th>NUMBER</th>
<th>COMPANY</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Interactive Tech, Inc.</td>
<td>Have package called RDM; runs on PDP-11s; written in Pascal</td>
</tr>
<tr>
<td>-2.</td>
<td>Computer Corp. of America</td>
<td>No knowledge of DBMS except for one at SAC.</td>
</tr>
<tr>
<td>3.</td>
<td>Technical Analysis Corp.</td>
<td>DBMS not available but have report generator which works on DG; uses business basic; sending info.</td>
</tr>
<tr>
<td>4.</td>
<td>Gamma Technology</td>
<td>Do not have DBMS; product line is commo interface for DG.</td>
</tr>
<tr>
<td>5.</td>
<td>Radian Corp.-United Products</td>
<td>DBMS is RELATE; core requirements are 64K bytes; modular structure; FORTRAN 4; callable subroutines; query language interface; cost: $1,000 monthly lease - $25K license. Sending info. Looks promising-developed on Eclipse.</td>
</tr>
<tr>
<td>6.</td>
<td>Tominy, Inc.</td>
<td>Product is Data Base-PLUS which runs on IBM series 1 using EDX or CPS. Written in host assembler.</td>
</tr>
<tr>
<td>7.</td>
<td>International Data Base System</td>
<td>DBMS is SEED running on DEC, IBM, MOD Computer, Prime and Perk &amp; Elmer; not on DG. Needs 40K for kernal program, another 64K for query language called &quot;Harvest&quot;.</td>
</tr>
</tbody>
</table>
8. **Global Computer Systems**

   Written in FORTRAN IV plus (66) and about 10% in assembler for machine I/O.

   Does not meet our applications but has DBMS of interest; runs on Reality machine made by Microdata; runs in assembly language using string handlers and dictionaries. Uses 6-7K bytes of OS and 16K bytes of storage. Being moved to Honeywell Level 6, PDP 11, Series 1 and HP through Microcode emulation.

9. **IBIS, Inc.**

   DBMS is INFORMAT - INFOTRIEVE for DG machines. Written in Business Basic and designed to run under their OS called "Interactive Operating System", uses 64K bytes of memory; costs $6K.

10. **AMCOR Corporation**

    Has DBMS for DEC machines, written in Basic II. No fit.

11. **Cybex Corporation**

    No DBMS however provided suggestions concerning addressing problem of RTOS.

12. **Panatec, Inc.**

    No "off-the-shelf" DBMS; their line is geared towards 8080/88 and written in "Pantabasic".
<table>
<thead>
<tr>
<th></th>
<th>Company Name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>13.</td>
<td>Royal International Software</td>
<td>No DBMS for micro-Nova, Nova or Eclipse.</td>
</tr>
<tr>
<td>15.</td>
<td>Software Module Marketing</td>
<td>Not in the DBMS business.</td>
</tr>
<tr>
<td>16.</td>
<td>Micro V Corporation</td>
<td>No one knew anything, sending literature.</td>
</tr>
<tr>
<td>17.</td>
<td>Percom Data Company</td>
<td>Not in DBMS business; sells peripherals.</td>
</tr>
<tr>
<td>18.</td>
<td>SCI Systems, Inc.</td>
<td>Does not have DBMS</td>
</tr>
<tr>
<td>20.</td>
<td>Practical Computer Systems</td>
<td>Disconnected number - no listing.</td>
</tr>
<tr>
<td>21.</td>
<td>MRI Systems Corporation</td>
<td>Deal with IBM, CDC and Univac; no support for mini/micro.</td>
</tr>
<tr>
<td>22.</td>
<td>Softool</td>
<td>Do not have DBMS; business is software development tools, automatic generation of code, standard documentation, etc.</td>
</tr>
<tr>
<td>24.</td>
<td>Plessey Peripherals Systems</td>
<td>They are a OEM company dealing with DEC only.</td>
</tr>
</tbody>
</table>
25. SD Systems, Inc.  "We don't have anything like that!!"

26. TASCIN Corp-Eidos Systems Corp.  Their environment is 8088 and Z80 vice DG line. They have two systems: KISS which is a ISAM and LISA which is a relational system.

27. Sentinel Computer Corporation  They do not support DG Nova or Eclipse line; they manufacture hardware and support it.

28. System Engineering Laboratory  They manufacture 32 bit computer; no general package available.

29. Polymorphic Computer Systems  Changed name to "Wild Hare". Indicated sending information about their DBMS for micro Nova and S140. Information received on time sharing package.

30. Pansophic Systems, Inc.  They do not support DG, Nova or Eclipse - deal in large frame - IBM 370.

31. Accurate Data Processing  Developed DBMS-2 for MOD computer; no longer support product.

32. Lockheed (LS+MS)  Nothing to offer.

33. Microbol, Inc.  Nothing to offer.

34. Incalon, Inc.  Nothing to offer.
35. Data Anilas Limited  Nothing to offer.
36. Informatics, Inc.  Nothing to offer.
37. Khalsa Research Corporation  No answer.
38. Century Computer Corporation  Will call back; never did.
39. CMC Marketing Corporation  Out of business
40. Computer Store  Retail - no DBMS
41. Hamby Hutcheson and Company  talked to his wife; not in DG.
42. Electronic Data Systems  Never called back.
43. Florida Computer  Deals only with IBM and DEC.
44. American Intelligent Machine  Deals in micro only.
45. Data Automation  Not in DG.
46. ACS Services  Out of business
48. Leeco  Has a file generator called "Dimension" product which works on DG; mostly a designers aid, sending information.
49. Adminis

Has DBMS called ADMINIS-president or salesman will call back.

50. Navelex

Gave POC at Lockheed for Outlaw Shark Project. Working on Navy DBMS called "Drums".

51. Complete Computer Systems

System called CREATE which is a system generator used to build file management DBMS; uses extended BASIC; runs on RDOS; mostly on Nova 4X; needs 500K? core; costs $15K.

52. Automated Quill

Menu-driven DBMS called "Super-English IX"; runs on RDOS and ADS on DG, 64K byte Nova. Other products are Super English II - Report writer, Superlabel, Supersetup.

53. Modular Computer System

Support only their line or process control computers.

54. Omni Unlimited

Product does not run on Nova or Eclipse.

55. Mountain Computer Inc.

Don't have DBMS - hardware only.

56. American Logica, Inc.

Has relational Data Base MS called Rapport in FORTRAN; running in England; has run in DEC, IBM, SAR, plans to move to Nova (despite literature); cost 12K to 32K; core 26 - 56K with query language.
<table>
<thead>
<tr>
<th></th>
<th>Company</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>57.</td>
<td>Univair, Inc.</td>
<td>Sending information in DATASTAR; CPM oriented.</td>
</tr>
<tr>
<td>58.</td>
<td>Exact Systems and Programming</td>
<td>DNA-4 runs on AOS, RDOS, macro assembler; data definition facility and data dictionary. Looks good.</td>
</tr>
</tbody>
</table>
ANNEX B

Field Exercises
JUNE 1982 FIELD EXERCISE
Purpose: To provide the capability of computer generation of the commander's report and of computer response to queries concerning status of friendly units.

Lessons to be Learned

Technical

The technical lesson to be learned will be establishment of a data base management system on the TCS.

Operational

Ability of the operator to input data.
Ability of the operator to generate commander's report.
Ability of the operator to establish queries.
Verify the meaningfulness of the information format.

Environment:
The data base management system will be established at the brigade, division, and corps G3 offices with data bases.

Users:
The users of the system are non-ADP personnel e.g., assistant G3s, operation NCOs, and other users.

Assumptions:
The TCS will have multi-users. The friendly information addressed is given in Enclosure I.

Special Requirements:
The TCS will have 196 K words of memory and 560 K bytes of secondary storage on a floppy diskette.
Friendly Information: This information reflects the status of friendly units two echelons below the force headquarters. Thus, at corps, friendly information is required to brigade resolution; division to battalion solution; brigade to company resolution; and battalion to platoon solution. The information items are:

1. Unit ID
2. Unit Mission
3. Unit CP Location (Main, TAC,) (UTM/DTG)
4. Unit Heliport Location (Main, TAC,) (UTM/DTG)
5. Subunit ID
6. Subunit CP Location (Main/TAC,) (UTM/DTG)
7. Subunit Heliport Location (Main, TAC,) (UTM/DTG)
8. Sub-subunit ID
9. Sub-subunit Location (Left and Right Coordinates and/or center of (UTM/DTG)
10. (Sub-subunit CP Location (Main, TAC,) (UTM/DTG)
11. Sub-subunit Heliport Location (Main, TAC,) (UTM/DTG)
12. Battle Resources by Sub-subunit, grouped by subunit (DTG)

Consisting of:

a. Tanks (Auth/OH/Color)
b. TOW/HAW (Auth/OH/Color)
c. Dragon/MAW (Auth/OH/Color)
d. Personnel (Auth/OH/Color)
e. Tank Ammo (Auth/OH/Color)
f. ITV/HAW Ammo (Auth/OH/Color)
g. 8 in HOW (Auth/Off/Color)
h. Diesel Fuel (Auth/Off/Color)
i. 155 HOW (Auth/OH/Color)
j. AVLB (Auth/OH/Color)
k. Commo Status (Color)
l. Sub-subunit Commander's Evaluation (Color)
m. ITV (Auth/OH/Color)
n. M1 (Auth/OH/Color)
o. M2 (Auth/OH/Color)
p. M3 (Auth/OH/Color)
q. M113 (Auth/OH/Color)
r. VULCAN (Auth/OH/Color)
s. CHAPARAL (Auth/OH/Color)
t. CEV (Auth/OH/Color)
u. ARTY Ammo (Auth/OH/Color)
v. LANCE (Auth/OH/Color)
w. LANCE AMMO (Auth/OH/Color)
x. 25mm (Auth/OH/Color)
y. SHORAD (Auth/OH/Color)
DECEMBER 1982 FIELD EXERCISE

Purpose: Add to the previously developed capability the following:

- Operate with up to four users on a TCS.
- Define geographic areas (circles, polygons, and thrusts).
- Provide security restrictions in the form of access controls to data in terms of "need to know" criteria.
- Other information including minefields, NBC contaminated areas and obstacles/barriers.
- Enemy information.

Lessons to be Learned:

Technical The ability of the TCS/DBMS to operate multi-tasking, multi-security level environment.

Operational The ability of the operators to use intelligence information, security controls, and other information. The ability of operators to define geographic areas.

Environment: Same as June 1982.

Users: Assistant G3/G3s and Operation NCOs.

Assumptions: Friendly information will address the level of detail two echelons below division and brigade, i.e., battalion and company, respectively.

Other information consist of:

- Mine field
  - Location (UTM/DTG)
  - Type of mine(s)
  - Estimated number
  - Density
  - Report of change
  - Date of time of deactivation
  - Location of lanes
  - Location of gaps
- Landmarks
- Method of delivery
- Enemy minefield
- Detection method
- Clearing method

- Nuclear fallout contamination
  - Type of report
  - Strike serial number
  - DTG of detonation
  - Location of attack (UTM)
  - Direction (left and right radial)
  - Effective wind speed km/hr
  - Down wind distance of Zone 1 (km)
  - Cloud radius (km)

- Nuclear residual radiation
  - Type of report (nuclear residual)
  - Strike serial number
  - Reference DTG for estimated contours or H-1 DTG
  - 1000 rad/hr contour line coordinates
  - 300 rad/hr contour line coordinates
  - 100 rad/hr contour line coordinates
  - 20 rad/hr contour line coordinates

- Chemical/biological contamination
  - Type of report
  - Strike serial number
  - DTG of detonation
  - Location of attack (UTM) (actual/estimated)
  - Location of contaminated area
  - Type agent

- Chemical/biological downwind hazard
  - Type of report
  - Strike serial number
  - DTG of detonation
  - Location of attack (UTM) (actual/estimated)
  - Direction (left and right radial)
  - Effective wind speed (KMPH)
  - Down wind distance of Zone 1 (km)
  - Cloud radius (km)
  - Type agent

- Obstacles/barriers
  - Type/Name
  - Location (point or area)
  - DTG

Enemy information consists of

- Type unit (unit designation, type unit, size)
- Location (UTM/DTG)
- CP location (UTM/DTG)
- Activity
  - Movement (DTG)
  - Combat activity
  - Mission
- Composition
  - Tanks (type)
  - APC (type)
  - Arty (type - highlight nuclear capable weapons)
- Strength (DTG)
  - Tanks
  - APC
  - Artillery
  - Personnel

Special Requirements: Same as June 1982.
JUNE 1983 FIELD EXERCISE
JUNE 1983 FIELD EXERCISE

Purpose: Add to the previously developed capability the following:

Establish of standing request for information (SRI).

Generate alert messages when SRI thresholds exceeded.

Lessons to be Learned:

Technical The ability of computer system to provide near real-time responsiveness to SRI, particularly those based on thresholds which require continuous accumulation of data as it is received.

Operational The ability of users to define SRI using data elements, time frames, and named areas of interest (NAI).

The usefulness of alert messages in terms of providing information to the decisionmaker.

Environment: Same as June 1982.

Users: Assistant G3/S3s and Operation NCOs.

Assumptions: Friendly information will address the level of detail two echelons below corps, division and brigade, i.e., brigade, battalion and company, respectively. Four SRIs will be available at any one time for each legal subscriber.

Special Requirements: Same as June 1982.
DECEMBER 1983 FIELD EXERCISE
Purpose: Add to the previously developed capability the following:

Planning data base at corps, division and brigade levels.

Provide redundant data bases at corps, division and brigade to enhance CONOPS.

Lessons to be Learned:

Technical The ability to derive the appropriate amount of redundant files and to provide the capability to re-establish a data base after failure, move, or temporary non-availability of capability.

Operational The ability of users to interact with planning data base.

The ability of users to re-establish their data base.

Environment: The capability will be established at corps and division G3 and the through brigade S3 offices, each with their data base.

User: Assistant G3/S3s and Operation NCOs.

Assumptions: Structure of planning data base will be identical to that of current friendly situation with the exception that a plain text planning identifier (plan name) will be added. Thirty-two planning files are available at each corps, division, and brigade. Capabilities are available for purging plan files; transferring data from a current to a planning file, for a planning to a current file, and from one planning file to another; and providing status of the planning files.

Special Requirements: Add the 1666B processor, up-grade the OS, and add militarized bubble memory.
JUNE 1984 FIELD EXERCISE
JUNE 1984 FIELD EXERCISE

Purpose: Add to the previously developed capability the following:

Refined SRI based on user feedback obtained in earlier field exercises.

Lessons to be Learned:

Technical  A more efficient SRI capability resulting from a clearer understanding of the user's requirements.

Operational Same as June 1983.

Environment: Same as June 1983.

Users: Assistant G3/S3 and Operation NCOs.

Assumptions: Same as June 1983.

Special Requirements: Same as June 1982.
Purpose: Add to the previously developed capability the following:

Distributed data bases where information is forwarded only when required.

Redundant data bases for this distributed approach.

Lessons to be learned:

Technical

The ability to provide required information in format needed.

The ability to parse query, generate the queries to proper locations, receive reply and format to respond to user without human intervention.

Operational

None

Environment: Same as June 1983 with exception of data processing philosophy.

User: Assistant G3/S3s and operations NCOs

Assumptions: None

Special Requirements: Consideration to adding either MCF OS or AOS/ARTS.