NAVAL POSTGRADUATE SCHOOL
Monterey, California

THESIS

DATABASE APPROACH FOR RESOURCE MANAGEMENT
AT ROK ARMY DIVISION LEVEL

by

Kim, Dae Sik
and
Kim, Soo Hyun

December 1987

Co-Advisor Daniel R. Dolk
Co-Advisor Shu S. Liao

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REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION/AVAILABILITY OF REPORT Approved for public release; Distribution is unlimited.
2b. DECLASSIFICATION/DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S)	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Naval Postgraduate School; 6b. OFFICE SYMBOL (If applicable) Code 54	7a. NAME OF MONITORING ORGANIZATION Naval Postgraduate School
6c. ADDRESS (City, State, and ZIP Code) Monterey, California 93943-5000	7b. ADDRESS (City, State, and ZIP Code) Monterey, California 93943-5000
8a. NAME OF FUNDING/SPONSORING ORGANIZATION; 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code)	10. SOURCE OF FUNDING NUMBERS: PROGRAM ELEMENT NO. / PROJECT NO / TASK NO / WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification) DATABASE APPROACH FOR RESOURCE MANAGEMENT AT ROK ARMY DIVISION LEVEL

12. PERSONAL AUTHOR(S) KIM, Dae Sik and KIM, Soo Hyun

13a. TYPE OF REPORT	13b TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15 PAGE COUNT
Master's Thesis	FROM ______ TO ______	1987 December	131

16. SUPPLEMENTARY NOTATION

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	Defense resource management system, Database management system, Decision support models

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

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20. DISTRIBUTION/AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS	21 ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED
22a. NAME OF RESPONSIBLE INDIVIDUAL Prof. Daniel R. Dolk	22b. TELEPHONE (Include Area Code) 408-646-2260; 22c. OFFICE SYMBOL 54Dk

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete

SECURITY CLASSIFICATION OF THIS PAGE

☆ U.S. Government Printing Office: 1986—606-243

Approved for public release; distribution is unlimited.

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by

Kim, Dae Sik
Major, Republic of Korea Army
B.A., Korea Military Academy, Seoul, 1979

and

Kim, Soo Hyun
Major, Republic of Korea Army
B.A., Korea Military Academy, Seoul, 1980

Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT

from the

NAVAL POSTGRADUATE SCHOOL
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ABSTRACT

This thesis is designed to propose the need for database establishment at the Army division level to improve the efficiency and effectiveness of the defense resource management system (DRMS). Since the DRMS requires complex and multi-faceted activities which includes financial, material, and facility data, the application of accurate and timely data is a crucial component. A limitation of the current resource management system is that it does not effectively satisfy the user's information requirements. A relational database system can facilitate to solve these problems by the report generator capability or ad hoc queries in a simple SQL query operation. Considering the current situation of the ROK Army division equipped with the computer mainframe, the initiation of this study can provide the ROK Army authorities or the computer experts with a motivation to develop the database system as the primary means of reinforcing the DRMS.

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I. INTRODUCTION

Korean military spending is reaching one third of the total government budget and 6% of GNP. In spite of this high proportion, the goal of self defense has not been accomplished. As a means of obtaining defense capability to balance military power between ROK and North Korea, greater efficiency and effectiveness in the use of defense expenditures is required.

It was not so long ago that the Korean Army paid attention to resource management. Even though we have run through a series of trial and error in the resource management system, we could not establish a well-developed system for controlling operational data and for measuring performance in terms of cost effectiveness analysis. Furthermore, the absence of reliable data about operating activities made it difficult to analyze and evaluate possible improvements.

A. THESIS OBJECTIVE

This thesis examines the current ROKA defense resource management system (DRMS) and proposes an DRMS database design at the division level to improve its efficiency and effectiveness.

Since the resource management system deals with very complex and multifaceted financial, material, and facility activities, the availability of accurate and timely data is a crucial factor in the successful allocation and expenditure of limited resources.

This thesis is developed around the following questions:

1. What is the current resource management system of ROKA?
2. What are the information requirements for the effective resource management?
3. How can a relational database management system support the resource management in the division level?
4. How can data manipulation of the relational model meet the diverse information requirements?
5. What capabilities exist for expenditure analysis and performance evaluation in this database environment?

The overall objective of the thesis is to propose a course of action to improve ROKA resource management system from the user's point of view, and to show the possible application of the relational model database in the data analysis.

B. THESIS ORGANIZATION

The thesis consists of 6 main chapters. Chapter II provides the overview of the current ROKA resource management system. Limitations as well as the status quo will be surveyed as the starting point of this thesis.

Clear identification of the information requirement is the fundamental matter for any database approach. In Chapter III, the user's needs are examined. The identification of required output data will provide the motivation for the database design.

Chapter IV introduces the principal concepts of the data management approach from the user's viewpoint. The main topics are: what is the database?; why do we need a database?; how is it operated?

The main research of the thesis will be performed in Chapters V and VI. In Chapter V, the actual transaction or activities of the resource management system are represented as tables to be manipulated in a relational database management system. (The relational model is widely accepted as a powerful and flexible database technique.) Examples are provided to show how to derive the required information by using the SQL data manipulation language. Chapter VI describes various analyses of the resource management expenditures which can be derived from this database. We will demonstrate the analysis with appropriate models in three cases.

Finally, based on the preceding research, we conclude the theses by proposing a course of actions to implement an effective and efficient resource management system in ROKA division level.

C. THESIS SCOPE

Throughout the thesis, the detailed technical issues on information systems and database design will not be covered, rather we focus on the application capability of the output data in the relational model. Since the urgent requirement for the ROKA in coping with the resource management is the availablity of the timely and accurate operational data, our main concern is a well-developed database system as the key element of the resource management information system.

II. REVIEWS OF REPUBLIC OF KOREA (ROK) DEFENSE RESOURCE MANAGEMENT SYSTEM

A. GENERAL

In order to provide funding for an increase in capital investment, in July 1983, Republic of Korea (ROK) President Chun issued an executive order requiring the Korean armed forces to reduce the operating expenditure in the nation's defense budget [Ref. 1: p. 3]. The objective of this order was to take initial steps toward improving defense resource management.

While the ROK economy has made excellent progress, defense spending is reaching 6% of GNP or approximately one third of the government budget. This figure is considered high by free-world standards. Despite this high level of spending, the imbalance of military power between the two Koreas remains in favor of the North as shown Table 1 [Ref. 2: pp. 59-63].

As a means of obtaining greater defense capabilities to balance military power between South and North, the Government of ROK has taken steps to obtain greater efficiency in its use of defense funding. Promoting the efficiency of defense operating expenditures will be the best way to accomplish the objective of self-defense.

B. REVIEW OF THE REPUBLIC OF KOREA DEFENSE RESOURCE MANAGEMENT SYSTEM

1. Background and History

U.S. security assistance to the ROK has played an essential role in strengthening the military capabilities of the ROK. In the past, Korea's main focus of defense management was to obtain as many resources as possible. Government policy makers didn't feel the need for advanced management systems and specialists to enhance defense productivity.

In the 1950s and 1960s, arms transfers from the U.S. were made under the Military Assistance Program (MAP); during the subsequent period of ROK Armed Forces Modernization Program (1971-1975), the military capabilities of ROK were greatly enhanced under such U.S. Military Aids Programs as MAP and the Military Assistance Service Fund (MASF).

Since the mid-1970s, U.S. security assistance policy toward ROK has undergone a tremendous change. Assumption of increased responsibility for its own

TABLE 1

COMPARISON OF MILITARY POWER BETWEEN SOUTH AND NORTH

Contents	ROK	North Korea	Rate
* Man power			
- Regular	622,000	785,000	1 : 1.3
- Reserve Forces	5,780,000	5,170,000	1.2 : 1
* Equipment			
- Artillery	2,800	5,300	1 : 1.9
- Tank	1,200	3,200	1 : 2.7
- Armored Vehicle	800	1,200	1 : 1.5
- Submarine	-	21	
- Destroyer	20	2	
- Naval Vessels	101	537	1 : 5.3
- Bomber/Fighter	450	740	
- Transporter	61	369	
- Total Aircraft	618	1,322	1 : 2.1
* Defense spendings			
- GNP(1983)	$ 75.3 B	$ 14.5 B	5.2 : 1
- Defense Budget	$ 4.34B	$ 3.4 B	1.3 : 1
- Cumulative total Since 1970	$ 28.53B	$ 31.4 B	1 : 1.1

defense made ROK MOD realize the need for a better and more efficient allocation of defense resources. Toward this end, the U.S.'s Planning, Programming, and Budgeting System (PPBS) was studied and introduced. Finally, the Planning, Programming, Budgeting, Execution, and Evaluation System (PPBEES) unique to ROK military needs was developed as shown in Figure 2.1 [Ref. 3: p. 86].

The concept of PPBEES is to design a bridge between the planning and programming phases and to feed back the results of performance evaluations for use in subsequent phases of planning, programming, and budgeting. Under PPBEES, increments to programs were considered in the programming phase and these increments were then translated into line item entries for the traditional budget submission. [Ref. 4: p. 91] This PPBEES system aims to develop a sound Defense Resource Management System by adding the execution and evaluation phases to the previous budget system.

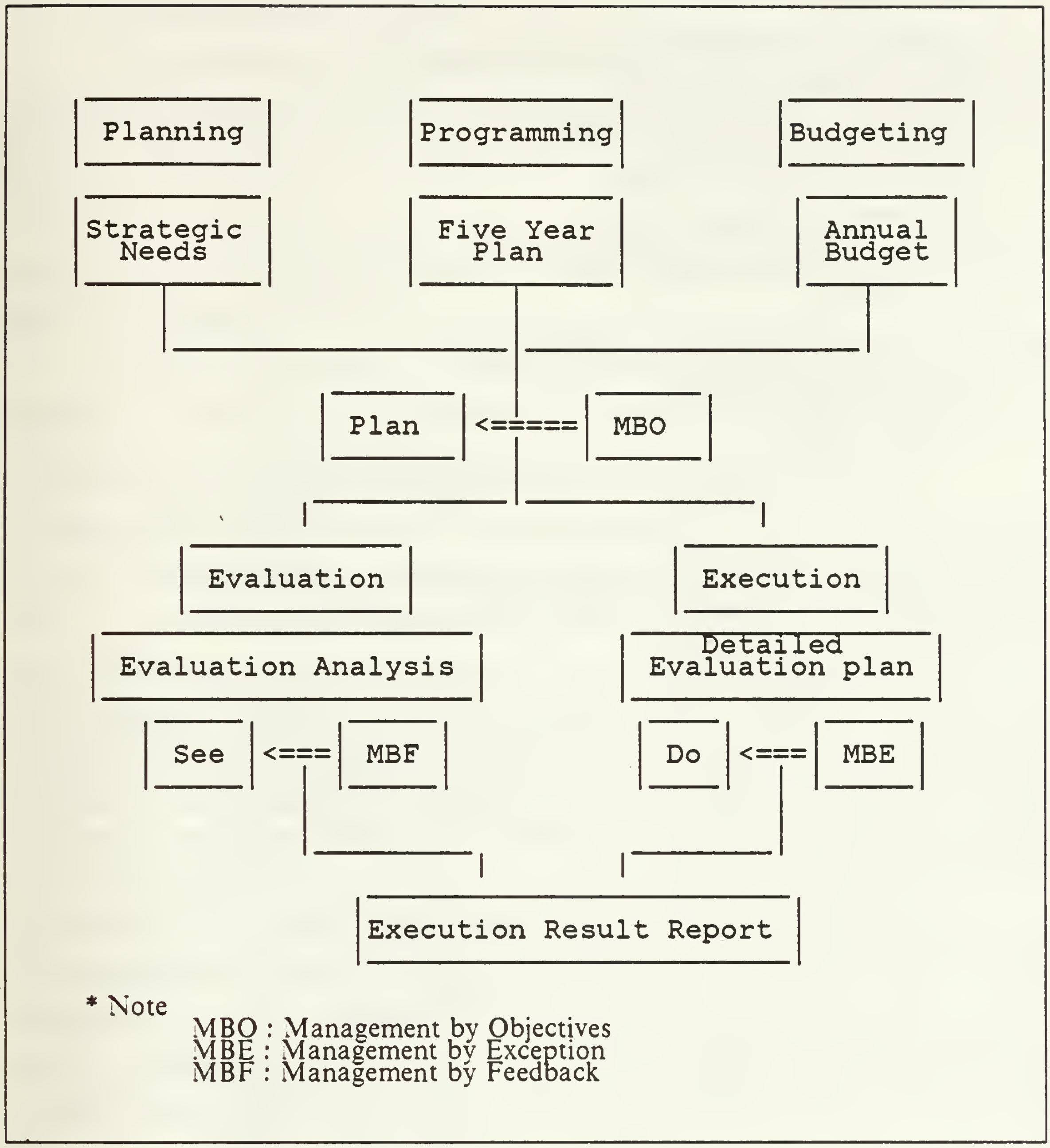

Figure 2.1 The PPBEES System.

On February 25, 1983, the Defense Budget Revolution Committee was established in order to make an intrinsic improvement in the defense budget system. Its main objective was to establish a rational cyclic process of planning, programming, budgeting, execution, evaluation. [Ref. 4: p. 7] The Budget Revolution Committee selected eight major functions to implement the PPBEES system. [Ref. 1: pp. 17-32]

The eight major functions are:

- Decision-making process
- Planning-programming process
- Program management system
- Decentralized management system
- Analysis and evaluation system
- Management information system
- Resource management staff function
- Reorganization

These are explained in detail in the following section.

2. Decision Making Process

a. Basic Concept

The process suggests that the national defense objectives be translated into budgetary decisions. After identifying alternatives necessary to carry out the mission, cost-effectiveness analysis for defense related programs are to be performed in order to determine the priority of alternatives within the given budget constraints.

b. Directions toward Reform

At the beginning stage, each project requires an analysis report to justify its budget request in detail; thus nonessential projects can be eliminated early. For the appropriate force-mix, first, we establish the strategy concept to meet the enemy's threat and then decide the resource allocation between each force (Army, Navy, Air Force, Homeland Reserve Forces).

In the past, the Korean government had focused on the process of obtaining a budget, therefore, the execution and evaluation phases were not considered in detail. There was no consistency in the management cycle of planning-programming-budgeting. Because of the abstract nature of programming criteria, planning was not sound. Distribution of defense resources, therefore, was inefficient, and the productivity of the defense budget was very low. [Ref. 1: p. 17]

3. Planning-Programming Process

a. Basic Concept

The concept of planning-programming process explains the process of budget organization. It is important to understand the roles of both long-range and short-term planning in the overall planning scheme. Requests for military forces to meet the strategic and force maintainance programming must be coincident.

b. Directions toward Reform

By integrating the Strength Improvement Plan[1] and Defense Five-Year Program,[2] the investment budget and operating expenditure could be allocated properly. The adjust and control function of budget programming would be strengthened.

Evaluation of projects can be performed more easily by using uniform documents in the planning, programming, and budgeting process as shown in Table 2. [Ref. 3: pp. 90-91]

It is then possible to manage defense projects more effectively. Each expenditure criteria derived from comparing the performance result of user-level units can be used as guidance for planning and budget organization. [Ref. 1: p. 19]

4. **Program Management System**

a. Basic Concept

Until now, weapon system procurement programs were performed by ROK MOD according to the Strength Improvement Program. However, the maintenance and supply support plans were performed by each service department, so, there were no responsibility centers for each stage. Korean military planners believe that each program must have consistency from beginning to end. Therefore, the weapon system selection phase, research and development, test and evaluation, production, quality assurance, procurement, deployment, and operation phases, all must have consistency. At the first stage, that program which has the highest priority is selected based on its level of investment or contribution to strength improvement (strengthening of war potential). Secondly, a project manager will be selected to improve the efficiency of program execution and management of weapon system organization and logistic support. The manager selected must be accountable and must be given the necessary authority to fulfill these responsibilities.

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[1]This plan started after the 8th session of the Korea-U.S. Ministerial Security Conference of August 1975. The principal ingredients of the plan are the increase of military hardware, the expansion of defense facilities and the development of the defense industry. At the begining stage, the primary fiscal sources were the national defense tax and U.S. financial support and other cooperation. Currently, the main source is the national defense tax.

[2]Based on the Strength Improvement Plan this program is aimed at securing a defense capability to repel north Korean Aggression unaided by China or Russia. This program called for the attainment of this goal within 5 years, starting from 1975. After the first 5-Year Program, however, every 5 years, new 5-Year Programs have been extended.

TABLE 2

DOCUMENTS IN PLANNING-PROGRAMMING-BUDGETING CYCLE

Month	Year X-3	Year X-2	Year X-1
JAN FEB	Long Range Strategy and Policy	National Strategic Objective Plan, Research and Development Plan	Military Budget Requirements
MAR	Middle Range Intelligence Estimation	Middle Range Defense Policy	-
APR	-	5 Year Plan Guidance, Strength Improvement Guidance	-
MAY	Strategic objective Guidance, Research and Development Guidance	-	Defense Budget Requirement, Service Improvement Executive Guidance
JUN JULY	-	Service Strength Improvement Requirement	Service Strength Improvement Plan
AUG	-	Service 5 Year Requirement	-
SEPT	Service Strategic Objective Plan, Service Research and Development Plan	-	-
OCT	-	Strength Improvement Plan	Defense Strength Improvement Execution plan
NOV	-	Annual Defense Policy	-
DEC	-	-	National Assembly Authorization and Appropriation

b. Directions toward Reform

Project management requires approval of high authority at key decision points (milestones). Life cycle cost (LCC) is considered on an equal basis with system performance, schedule, and logistic supportability. A clear line of authority, responsibility, and accountability for the management of programs is established. Competition in contracting is also required. [Ref. 5: pp. 36-38]

5. Decentralized Management System

a. Basic Concept

The unit commander has the responsibility for managing the unit's resources such as manpower, funds, materials, and facilities. Complete autonomy in spending on the part of the operational commander is emphasised. First, the commander will be motivated to control costs by establishing his ownership and responsibility to manage his unit efficiently. Secondly, each soldier will be motivated to find cheaper substitutes, because the remaining funds which result from efficient management could be used for the soldiers' welfare, such as recreation facilities, a library, sport equipment, etc.

By developing a proper accounting report system, it is possible to estimate the performance of each unit and summarize aggregate totals. For example, 1/4 ton jeep operation can be divided into 3 categories according to the following purposes : commanding, operation, and administration. The maintenance cost per vehicle could be compared with that of the same purpose vehicle of other troops, but it is difficult to say that lower cost always means better performance.

b. Directions toward Reform

By strengthening the function of resource management, each unit commander can assess his unit's assets and make an analysis of the results of his resource spending, which can facilitate economic troop management. To establish the management information system, it is necessary to first develop a new accounting system that can integrate the total resources and adopt the user-centered logistic management which is based on decentralized principles. [Ref. 5: pp. 34-36]

6. Analysis and Evaluation System

a. Basic Concept

This system was established to provide basic data needed in successive planning, programming, and budget compilations. The basic data can be derived from the result of comparative analysis between the required mission performance level and the results of resource spending.

b. Directions toward Reform

The mission performance level and the result of resource spending could be analyzed and evaluated by developing a new accounting system and the establishment of a new auditing policy which is consistent with the concept of resource management. At the programming and budgeting stage, the previous data of expenditure analysis could be used to make programming decisions as well as budget formation based on performance criteria.

7. **Management Information System (Computer-Based)**

a. Basic Concept

In order to operate the Defense Resource Management System efficiently, information (demand, procurement, operating-inventory control, performance evaluation...) must be provided at the right time and right place. This system must be computerized to obtain the benefits of speed and accuracy. This system also can assist in decision making for resource allocation.

b. Directions toward Reform

DBMS (Data Base Management System) was established to assist the process of analysis, evaluation and the accurate computation of resource demands. Constructing computer networks among MOD, each division of the Army, Naval theatre commands, and Air Force flying corps will facilitate this process. [Ref. 6: p. 13]

Computerized inventory management of logistic materials and other major resources can facilitate the decentralization of the resource management system, which includes procurement, storage, and distribution procedures. Computerizing the process of 5 year programming, budget organization, and execution, can accomplish the objective of budget revolution in a short time.

8. **Resource Management Staff Function**

a. Basic Concept

Strengthening the function of the resource management staff is intended to support the decentralized unit management system by properly giving incentives to the units according to their performance.

b. Directions toward Reform

Three separate functions (finance, logistics, and facility engineering) were integrated and the overall management staff controls all resources. The overall management staff is responsible for all resource management in the unit, and so seeks the most economic level of unit operation, prepares the unit's budget, and handles material accounting and fund accounting. [Ref. 1: p. 31]

9. **Reorganization**

a. Basic Concept

The newly designed Defense Resource Management System is based on the concept of PPBEES (planning, programming, budgeting, execution, evaluation system). Thus, a new organizational structure is needed to support the new procedure. This will require integration, restructuring and reinforcement of the new system to reorganize the current structure to meet the new task.

b. Directions toward Reform

The old structure must be reconized through changes based on an integrated logistic system. A part of the new organization must be a cost and program analysis function which should be accomplished through a special organization manned by professional personnel. [Ref. 1: p. 32]

After introducing the Defense Resource Management System in 1983, ROK MOD has made a concreted effort to implement the system in the ROK military as follows:

- Selection of the sample units according to the type of troops.
- Design of the common structure documents used in the programming and budgeting phases.
- Implementation of the system in the experimental troops.
- Evaluation of the performance results in the experimental troops.
- Amendment and reinforcement in the intrinsic nature of Defense Resource Management System introduced.
- Inspection of the execution of the system.

Finally, from the beginning of 1986, the Defense Resource Management System is being implemented throughout the MOD. The Defense Management Accounting System is designed to assist the newly proposed Defense Resource Management System. The objective of this system (procedure) is to provide standardized data for resource management to each level commander. [Refs. 7,8] Accounting information has two major purposes : decision making and performance evaluation. For example, managers can easily decide the proper disposal time of an equipment by using the accounting information. Regression analysis is one of the common techniques to produce the accounting information.

The Defense Management Accounting System is intended to support not only the decentralized unit resource management system, which is one of the eight major functions of the budget revolution movement, but also the PPBEES which is the main objective of the defense management system.

Until 1984, legal accounting procedures had been used to provide the legal result of resource expenditures. The private sector's accounting theory was adjusted to meet the characteristics of military needs. The analysis of performance and resource spending results can now be obtained through cost analysis.

To accomplish this new accounting procedure, the Budget Revolution Committee adopted the unified accounting system based on the double entry bookkeeping principle. Everything that has any economic value must be recorded and analyzed according to the proposed accounting system. For example, suppose that there is a useful plant on the base; the monetary value of the plant must also be evaluated according to its growth, so annually, or at every prescribed term period, its value must be reevaluated.

Two different kinds of accounting methods are used, according to the type of unit. The corporate accounting system (also called special accounting) is adapted to production, maintenance units and education units. On the other hand, general combat units use a different accounting system from the corporate accounting system. This is called the general accounting system and is similar to U.S. Government accounting procedures.

The general accounting system does not permit the concept of depreciation, which is regarded as an expenditure at the time of disposal. Prepayments are also regarded as expenditures not as assets, which make up the capital. In the general accounting system, bonus payments are recognized at the point of occurrence, but in the special accounting system, the average of payments is recorded as expenditures in each period. Classification of expenditure as direct and indirect is needed in the special accounting system but not in the general accounting system.

C. CURRENT RESOURCE MANAGEMENT SYSTEM

Resource management system (RMS) are a series of systems designed to promote better management through the ROK MOD by providing managers with improved means of obtaining and controlling the resources required to accomplish missions. They also include procedures which are closely related to quantitative systems even though the system may not themselves be primarily quantitative. Resources are men, materials, services, and money.

A resource manager is any individual who is responsible for carrying out a significant mission or function and who in so doing makes decisions that have a significant effect on the resources used. For the military commander this means that responsibility for management is added to the traditional responsiblity for command.

1. Objectives of RMS

The objectives of RMS are:

- to provide managers at all levels within the ROK MOD with information that will assist them in assuring that resources are obtained and used effectively and efficiently in the accomplishment of MOD objectives.
- to provide information that useful in the formulation of objectives and plans.
- to provide data to support program proposals and requests for funds.
- to provide a means of assuring that statutes and other requirements relating to resources are complied with. [Ref. 8: p. 11]

2. Structure of RMS

The structure of RMS is designed to establish the criteria of each management accounting unit and lead each unit to have responsibilities for its resources and consumption of the resources. Through the structure of RMS it can be possible to measure the resource requirements that each management accounting unit needs, to motivate a resource manager by comparing with the performance of other unit, and to vest the authorities and responsibilities of resource management in resource managers.

The structure of RMS consists of five levels, such as command and control unit, mid-management unit, resource management unit, expense collecting unit and consuming unit as shown in figure 2.2. [Ref. 8: p. 20] Higher level unit controls lower level unit and lower level unit report to the higher level.

a. Command and Control Unit

Command and control unit is the top management level which collects, analyzes, and evaluates all kinds of reports, determines the standard expenses, and is concerned with establishing policies and developing plans. Ministry of Defense (MOD) and ROKA Headquarters are the command and control units.

b. Mid-level management unit

Mid-level management unit is the second highest management level that collects various reports from subordinate units,puts the reports together, and reports them to the command and control unit. Headquarters of Field Army and Corps are mid-level management units. Mid-level management unit becomes a management accounting unit and has a responsibility for the resource management and reporting to the higher level.

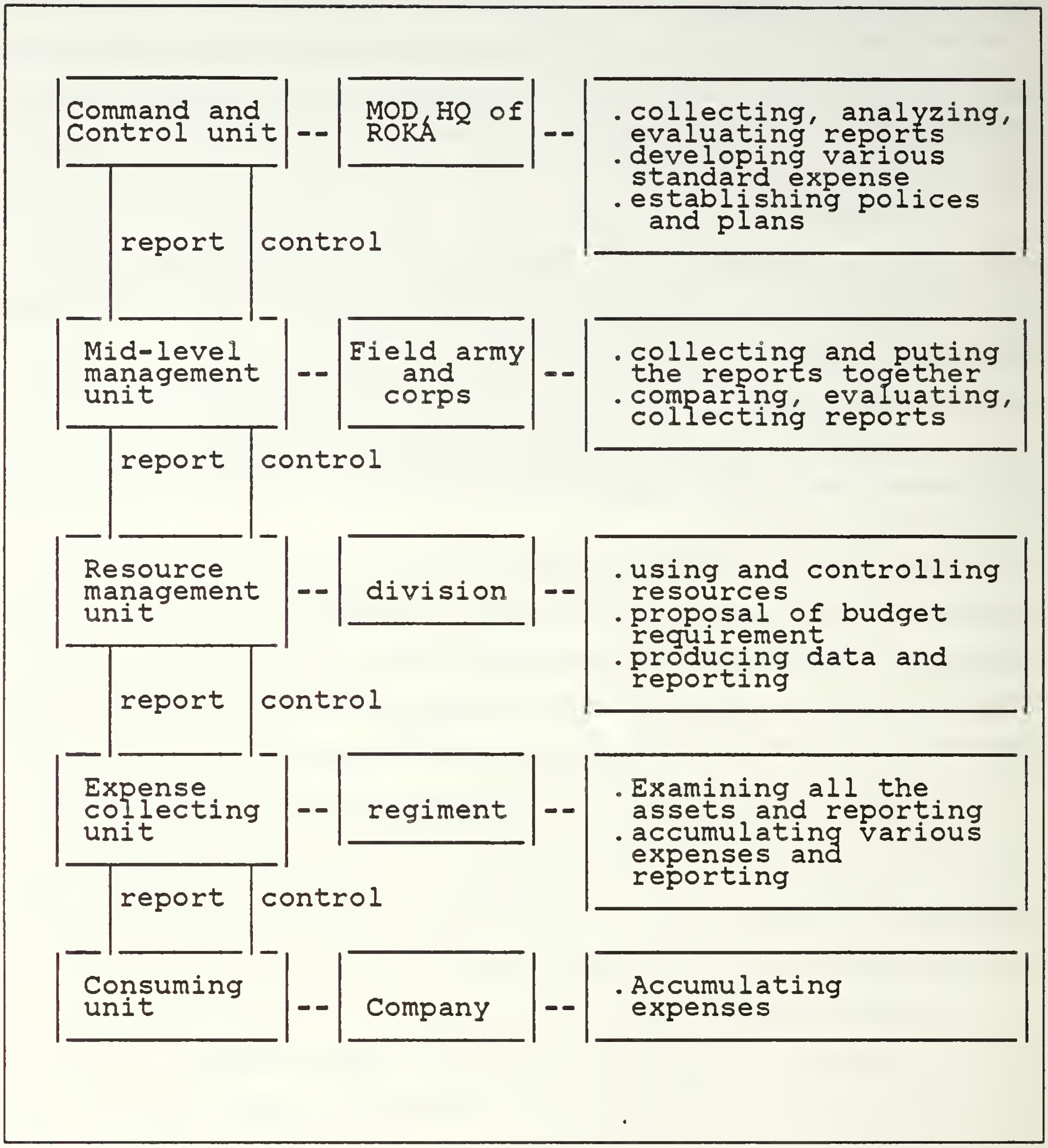

Figure 2.2 Structure of RMS.

c. Resource Management Unit

Resource management units are the principal and elemental units of resource management which are concerned with estimating budget requirements, using and controlling resources, and producing various managerial data and reports. It has a responsibility for reporting to the higher level. Typically, Army divisions become resource management units.

d. Expense Collecting Unit

Expense collecting units are the subordinate unit of resource management units, such as Infantry Regiments, which record various operating expenses, prepare periodic reports, and report to the resource management unit according to directions and coordinations of the upper level unit.

e. Consuming Unit

Consuming units are the lowest subordinate units of expense collecting units,these are usually companies. The consuming unit records all kinds of expenses whenever consuming events occur and report to the expense collecting unit through the simplest channels, such as telephone, oral message, messengers.

f. Unit Identification Code

Unit identification code is designed to computerize the processes that continuously accumulate all the expenses resulting from using the resources of a unit. In the resource management system for operations the unit identification code is the basic classification device whereby expense information is related to a program. ROK MOD makes the unit classification code and manage it and the unit classification code is created in a manner as shown in Figure 2.3. [Ref. 8: p. 21]

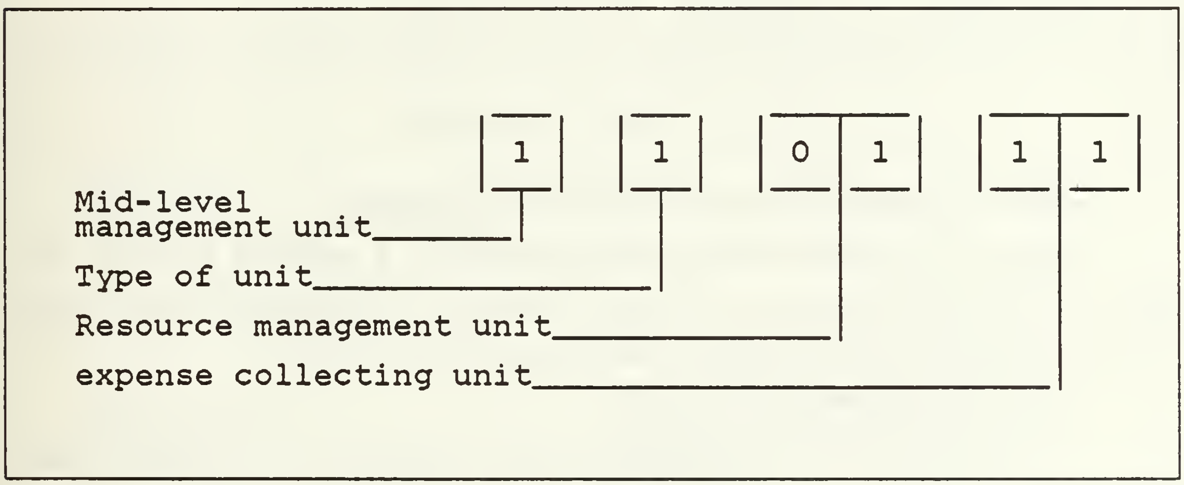

Figure 2.3 Unit Classification Code.

3. Accounting Records and Files

Accounting records required under RMS are made up of ledgers, journals, basic cost records, and control records. The number and kinds of journals, ledgers, and other documentation records required depend upon the type and volume of transactions, the desires of the major claimant, and the nature and level of the unit mission and organization.

The general ledger is the book of accounts in which all accounting entries are ultimately summarized. A general ledger is maintained for each unit activity. The account structure in the general ledger is specifically designed to accumulate financial data necessary to render meaningful reports to management. The chart of accounts carried in the general ledger is shown in Figure 2.4. [Ref. 8: pp. 25 - 69] Not all accounts listed will be found in all general ledger; Only those used by the unit activity holding the operating budget are found in the general ledger at that unit activity.

Major Classification	Account series
Asset accounts	1000 - 1999
Liability accounts	2000 - 2999
Capital accounts	3000 - 3999
Budgetary accounts	4000 - 4999
Contra accounts	5000 - 5999
Expense accounts	6000 - 7000

Figure 2.4 Chart of Accounts.

4. **General Procedure of Resource management Accounting**

Resource management accounting procedure is a series of processes that consists of identifying transaction, recording transaction, accounting process, closing entry, and preparing reports as shown in Figure 2.5. [Ref. 8: p. 74]

a. Identifying Transaction

A transaction means an activity that is recognized as accounting events associated with resources of a unit. In general, events are recognized as transactions only if they receive, transfer, release, or consume resources.

b. Recording Transaction

A resource transaction slip (RTS) is recorded whenever transactions occur. RTS is a kind of computer input document designed to process various resource transactions through a computer as shown in Figure 2.6. [Ref. 8: p. 153]

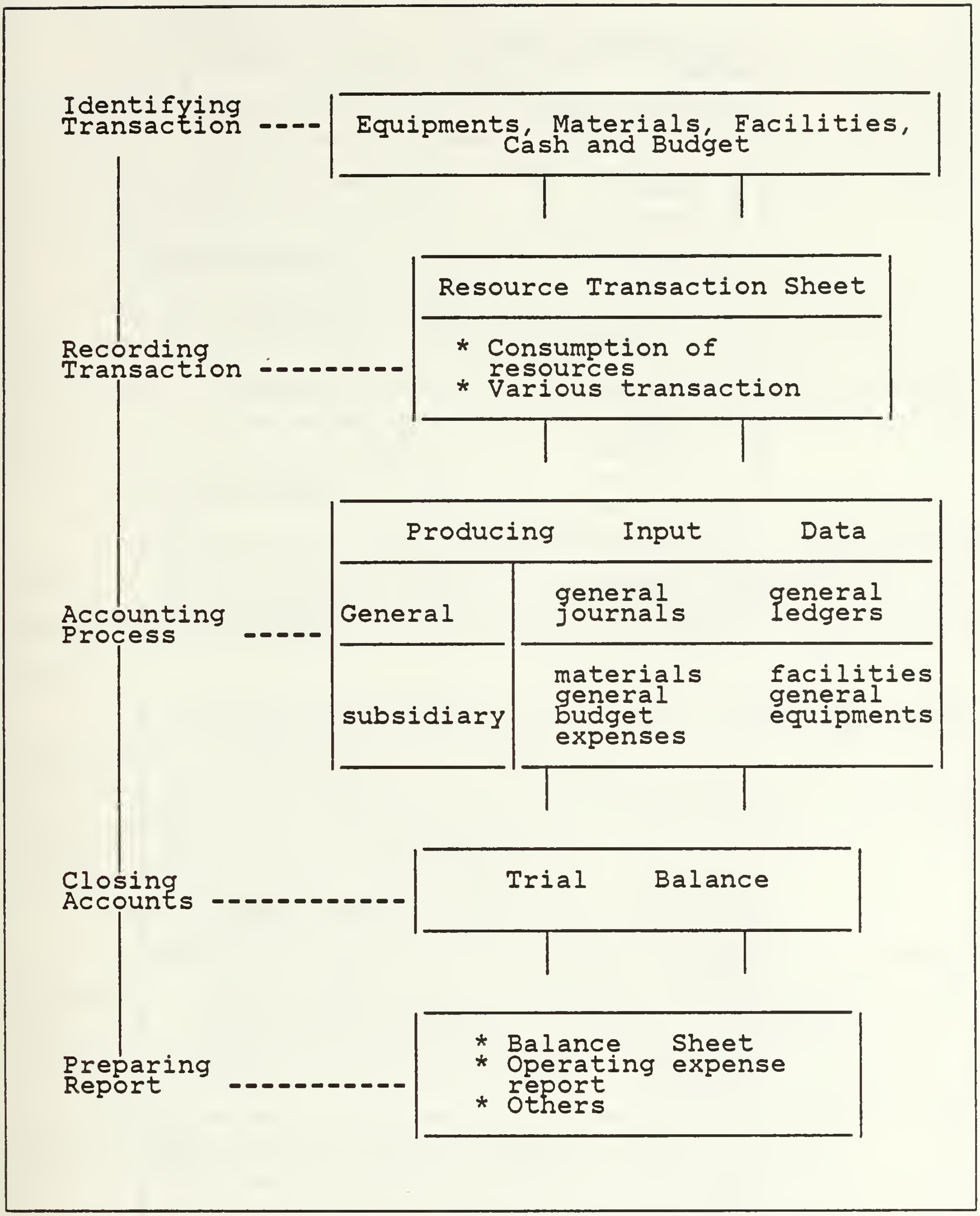

Figure 2.5 Resource Management Accounting Procedure.

The results of consumption of the expense collecting unit and various resource transactions (supply transaction, budget transaction, maintenance transaction, gratuitous transaction, allotment transaction, and others) are recorded in RTS.

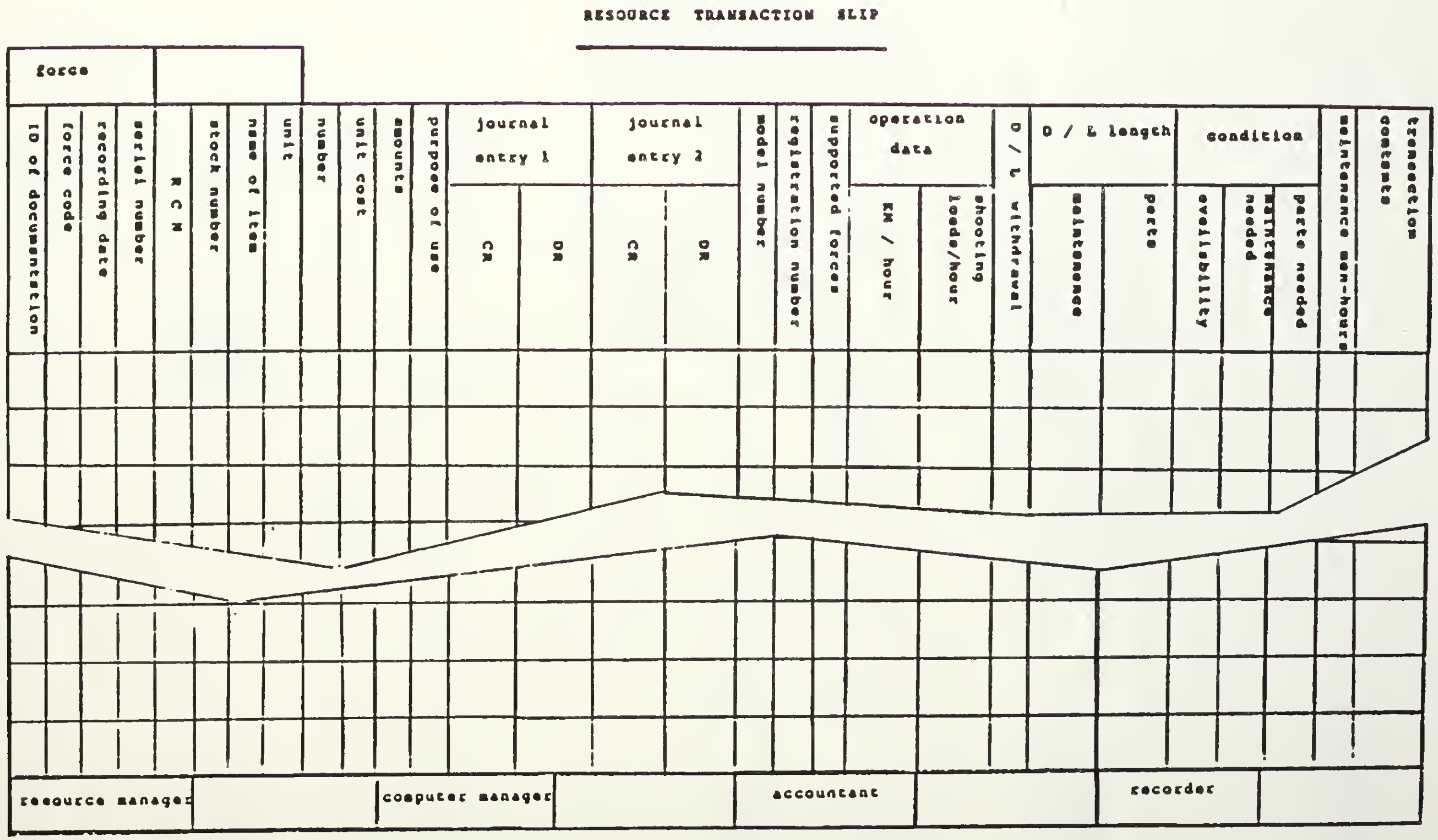

Figure 2.6 Resource Transaction Slip.

c. Accounting Process

In this stage, resource transaction slips are examined and modified when omissions, overlaps, or errors are found. A transaction file is produced by inputing all the resource transaction data. A Journal file is created from the transaction file thereafter. All the transactions of the journal file are recorded in the general ledger and each subsidiary ledger.

d. Closing accounts

Closing accounts is a procedure for preparing a trial balance, adjusting entries and various reports at the end of each quarter or year. A trial balance is a listing of each of the accounts in the general ledger with its balance at a particular time. All accounts with debit and credit balances are listed and summed. Closing accounts occur quarterly and yearly.

e. Preparing Report

Reporting is one form of responsibility accounting. The commanding officer (CO) has at his disposal a number of management and financial reports under RMS. Some reports are used by the CO; others are forwarded to the management echelon.

Reporting provides information on the operating expenses and obligations, operating budgets, and performance of field activities.

Reports forwarded upward are briefly listed in Figure 2.7. [Ref. 8: p. 86] Reports for the CO are very flexible depending upon characteristics of a unit, but now they are not established well in current RMS.

5. Current computer flowchart of RMS

A computer-based system was regarded as the key tool in the successful implementation of RMS, and each resource management unit (Army division level) was linked to the computer mainframe. However, the computer system for RMS was installed without sufficient preparation and experience, and it is undergoing deficiencies in its operating system and is not meeting the total user's needs. Current computer flowchart of RMS is shown in Figure 2.8. [Ref. 9: p. 7]

D. LIMITATIONS OF CURRENT RMS

The importance of MIS as an efficient tool to carry out the PPBEES system was perceived and the distributed computer system was implemented at the Army division level by the end of 1986. The computer is now used to perform the resource management work, but at the primitive stage.

NO	REPORT NAME	CONTENTS
1	Balance Sheet	* All assets and resource transactions of a unit.
2	Operating expense report	* Operating performance and expense of the unit's resources.
3	Expense management report	* Total amount of each expense elements. * Comparison of each unit's expenses. * Expense data of each equipment. * Expense data of each facility.
4	Equipment management report	* Operating performance of each equipment. * The present condition of each equipment.
5	Facility management report	* The present position of each facility.
6	Material management report	* The present position of each unit's materials. * Material transaction and its performance.
7	Budget control report	* Performance of use of cash and budget.

+ Responsible Unit: Resource Management Unit.
+ Term of each report: Quarterly.

Figure 2.7 Reports forwarded upward.

The ROK Army is striving to improve the efficiency and effectiveness of its defense resource management. However, it is experiencing some problems in the RMS which is caused by insufficient preparation and inexperiences in its early stage.

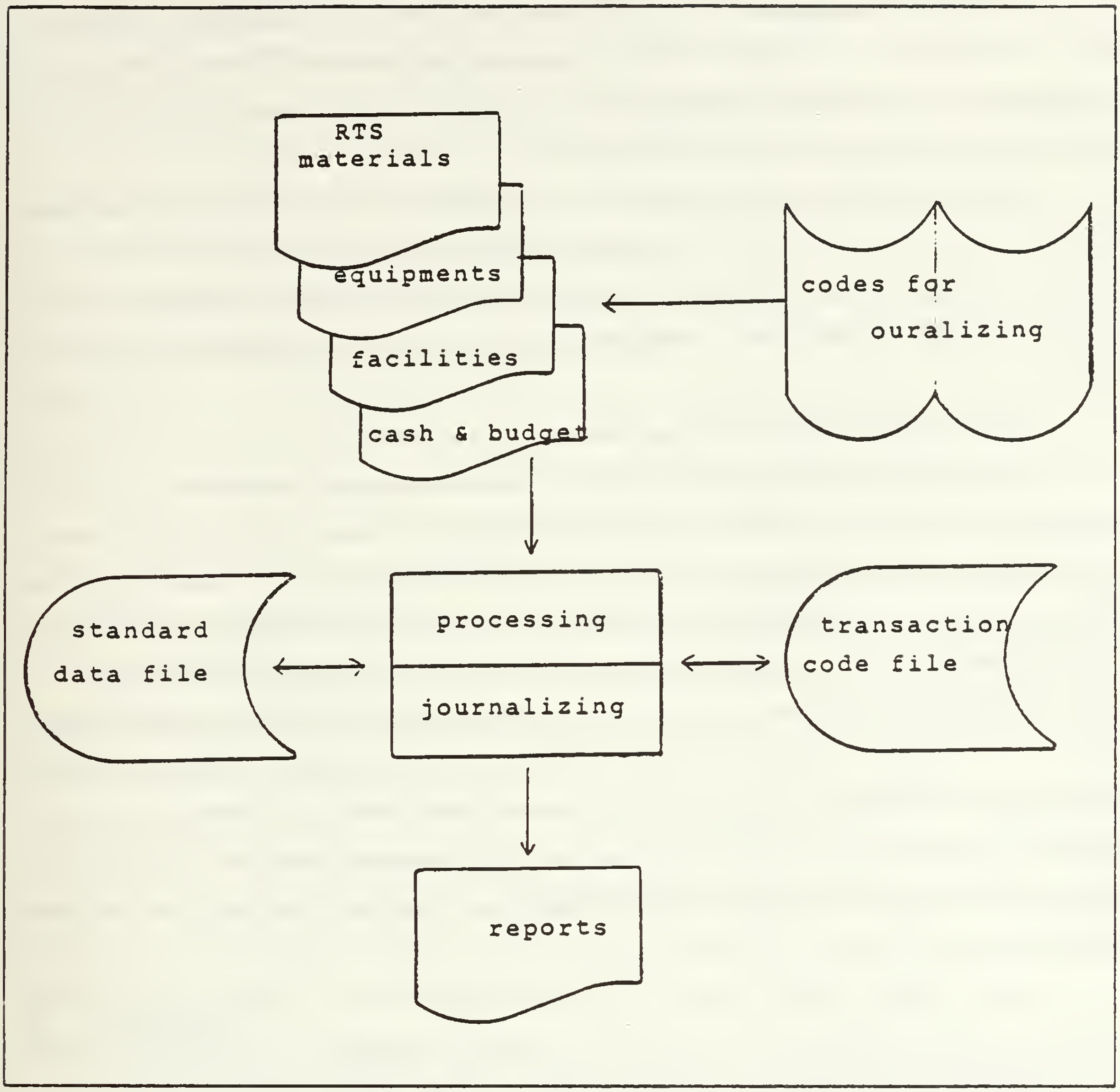

Figure 2.8 Flowchart of RMS.

1. **MIS and Data Analysis Models**

Decentralized management system, one of the eight major functions to implement the PPBEES system, is highly recommended for use in the ROK Army. Every unit is classified into eight unit categories: combat unit, logistics & support, intelligence, communication, headquarters & administration, hospital, school/institute. Each unit has its own mission and characteristics, therefore each unit must have its own budgeting, controlling, and evaluating system. To get the useful information for decision making, each unit must have its own MIS.

However, in current RMS a different unit has the same ready-made MIS which is developed in the highest echelon. Because the current MIS was developed to be suitable for Army division level, the Korea Army has experienced many difficulties in applying the current MIS to the different kind of unit.

Similarly, because each unit does not have the specific and well-developed analysis models, there is no way to compare the performance of each unit to the other. In order to compare and evaluate the performance, each unit must have its own MIS and data analysis models that is possible to get the useful information for decision making.

2. Financial Data and Operational Data

Management information helps the resource manager of each unit to make the best decision and it is produced, processed, and used through MIS. Management information can be divided into two classes: financial data and operational data. The Korea Army gets the financial data through the management accounting and can obtain the operational data by using or applying statistical theories and techniques.

The operational data is, in a sense, more important than the financial data, because it is closely related to a more effective measurement - combat material readiness and availability. However, the current RMS does not provide sufficient operational data even though the Korea Army has a requirement to maintain the reliable operational data which can explain the activities or purposes of the expenditure.

Data analysis models could not be developed without sufficient and reliable operational data. Furthermore, the combat material readiness and availability could not be measured well without the data analysis models. This problem was moreover complicated by using a unified single format RTS to record all the resource expenditure data of the unit which is discussed next paragraph.

3. Resource Transaction Slip (RTS)

RTS was designed to collect and accumulate all the data about the uses of each unit resources by the Defense Budget Revolution Committee, but it contains intrinsic problems in its use.

An Army division has seven classes of floating assets by and large: (1) cash, (2) foods, (3) petroleum & oil, (4) ammunitions, (5) repair parts, (6) individual maintenance materials, & (7) troop maintenance materials. The expenditures and transactions activities on each resources should be recorded in a separate relation, according to its unique characteristics. However, the 7 categories of the resources are required to be recorded in the single format of RTS.

The RTS has only 30 items to be described. The 30 items can not include all the facts that are needed to process information for decision making. Only a few Of 30 items are actually used in recording one transaction or activity of the resources, that is, the rest of 30 items is not necessary and redundant.

With the current RTS, it is impossible to calculate all the training expenses including petroleum & oil, repair parts, individual or troop maintenance materials, ammunitions, and cash that are used in the regiment combat training (RCT). Additionally, it is impossible to know the operational performance of the various vehicles of each unit, and to accumulate the operating expenses of each unit facilities.

The RTS is the source of all the data needed in the resource management system. However, the data gathered by the RTS are not entirely useful for the performance evaluation, problem identification, retirement decision of a equipment, and readiness or availablity measurement of each unit. Data do not have any value in themselves, but the value is determined depending upon the objective of data and how they are used in the analytical models.

In order to acquire the most useful information for decision making, the analytical models are developed and established, but more important thing is to analyze the data requirement. Therefore, the RTS should be redesigned to meet the information requirement resulting from the proper analysis of data requirement.

E. SUMMARY

The Republic of Korean Military has begun to recognize the need for budget revolution because the U.S. Military Aid Program has greatly diminished since 1970's. It has adopted a newly designed defense resource management system (DRMS). The objective of DRMS is to achieve efficiency and effectiveness in military spending by the use of a newly-designed PPBEES, new staff structure, modern financial accounting techniques, program management system, management information system, and a new organizational approach.

In this chapter we have reviewed the new DRMS implemented completely at the beginning of fiscal year 1986 and discovered the limitations of DRMS; (1) negligence of operational data that is indispensable for analysis and evaluation system, (2) unsuitable and insufficient data collection method, and (2) no data analysis models, caused by the insufficient preparations and inexperiences. Because of those limitations, the current

DRMS could hardly meet the initial purpose which was to create the performance criteria and decision-making information for each unit's efficiency and effectiveness mentioned above. This background will aid in understanding the main point of this paper: The database approach of DRMS at ROK Army division level.

The next chapter will develop the information requirement of ROK Army resource management system which is able to achieve the original goals of DRMS. The information requirement must be analyzed to meet all the needs of current management information system and data analysis models that will be developed in the future.

III. INFORMATION REQUIREMENT FOR THE DRMS OF ROK ARMY

A. CONCEPTS AND PROCEDURES OF INFORMATION REQUIREMENT DETERMINATION

Correct and complete information requirements are key ingredients in planning organizational information systems, implementing information systems applications, and building databases. Major information system applications integrated with databases require careful planning and significant cooperative effort between users and information system professionals.

Information requirement determination is a vital part of this cooperative activity. Although users are the fundamental source of requirements, they often lack the experience to accurately define them. Inexperienced analysts often feel that users should tell them what the information requirements are so system design and implementation can be developed. Experienced analysts know that eliciting correct and complete requirements is one of their most challenging tasks.

Since a database management system must ultimately provide service for end users, careful attention should be given to their needs. The users may be anyone outside the organization, operational management, high level management, or any combination of these. Interviews with the users should be done during the design stage and also when the first phases of implementation are completed to solicit feedback for modification of the system. If the data base management system does not meet the user's needs, then it will fail no matter how clever and sophisticated the technical design.

Information requirements are required at the organization-wide level for information system planning, identifying applications, and planning an information architecture. More detailed information requirements are required for design of applications.

How can accurate and complete information requirements be identified? Because of the constraints on humans as specifiers of information requirements, the users can not identify them all. Eliciting correct and complete requirements is one of the most challenging tasks. Both users and analysts should better understand the process of determining information requirements and improve their performance in this area.

An information system should meet the needs of the organization it serves, and applications should meet the needs of their users. The requirements for the information system are therefore determined by the strategies, goals, procedures, and behavior of individuals within the organization acting individually and collectively. [Ref. 10: p. 474].

In order to effectively analyze organizational information requirements, a four step process is presented:

1. Three level of information requirements
2. Analysis of organizational information requirements
3. Strategies for determining information requirements
4. Selecting a strategy for determining information requirements

1. The Three Levels of Information Requirements

There are three levels at which information requirements needs to be established in order to design and implement computer-based information system:

a. The organizational information requirements to define an overall information system structure and to specify a portfolio of applications and databases.
b. The requirements for each database defined by data models and other specifications.
c. The detailed information requirements for an application.

a. Organizational-Level Information Requirements

Information requirements determination at the organizational level is a key element in developing an information system master plan. The process of organizational level information requirements determination obtains, organizes, and documents a complete set of high-level requirements. The requirements are factored into databases and subsystems that can be scheduled for development. The overall information architecture is defined, and the boundaries and interfaces of the individual application subsystems are specified.

b. Database Requirements

Database requirements arise both from applications and ad hoc queries. The overall architecture for the databases to meet these requirements can be defined as parts of organizational information requirements. Major classes of data are defined and associated with organizational processes that require them. There is very little detail in the requirements at this level.

The process of obtaining and organizing more detailed database requirements can be divided into defining data requirements as perceived by the users and defining requirements for physical design of the databases. User requirements are referred to as conceptual or logical requirements because the user views of data are separated from the organization of data in physical storage. User requirements may be derived from existing applications or by data modeling.

c. Application-Level Information Requirements

An application is a subsystem of the overall information system structure; it provides information processing for an organizational unit or organizational activity. The process for the determination of information requirements at the application level defines and documents specific information content plus design and implementation requirements.

There are two types of information system application requirements: social and technical. The social or behavioral requirements, based on job design, specify objectives and assumptions such as the following:

- Work organization design objectives
- Individual role assumptions
- Responsibility assumptions
- Organizational policies

The technical requirements are based on the information needed for the job or task to be performed. They specify outputs, stored data, and information processes. A significant part of the technical requirements are associated with the structure and format of data. The technical requirements include interface requirements between the user system and the application system. The interface requirements include data presentation format, screen design, user language structure, feedback and assistance provisions, error control, and response time. [Ref. 10: pp. 475 - 476].

2. Analysis of Organizational Information requirements

Once goals and strategy have been delineated, the next stage is to obtain organizational information requirements. Although the level of specification is different for the organization and application, many of the methods for obtaining requirements are the same. Obtaining organizational information requirements consists of several steps:

a. Define underlying organizational subsystems
b. Develop manager by subsystem matrix
c. Define and evaluate information requirements for organizational subsystems

a. Define Underlying Organizational subsystems

The first phase of analysis is to define underlying organizational subsystems. The purposes of activity subsystem identification is to subdivide requirements determination by major organizational activity and make the process more manageable. The subsystems are obtained by an iterative process of discussing all organizational activities with managers and defining the activities as belonging to broad categories of subsystems. As new activities are considered, they are placed in previously defined categories, or a new category is created.

b. Develop Subsystem-manager Matrix

Once the underlying organizational subsystems are defined, the next phase of the organizational information requirements analysis is to relate specific managers to organizational subsystems. The matrix is prepared by reviewing the major decision responsibilities of each middle to top level manager and associating decision making with specific subsystems. The matrix identifies the major decision-making responsibilities for each subsystem. The purpose of this step is to clarify responsibilities and identify those managers to be interviewed relative to each subsystem.

c. Define and Evaluate Information Requirements for Organizational Subsystems

This step obtains the information requirements of each organizational subsystem by group interviews of those managers having major decision-making responsibility for the subsystem. Merely asking managers to define their information requirements is frequently not satisfactory because of the limitations on humans as information processors. It is therefore necessary to provide some structure to aid managers in thinking about information requirements.

The questions used in eliciting information requirements are derived from three approachs. These questions reflect three ways of thinking about requirements, but each question also delineates unique requirements. The use of the three types of questions therefore increases the probability of obtaining a complete set of requirements. The three questions are:

- What problems do you have and what information is needed for solving them? What decisions do you make and what information do you need for decision making?
- What factors are critical to the success of your activity and what information do you need to achieve success in them or monitor progress?
- What are the outputs (the ends) from your activities and what information do you need to measure effectiveness in achieving the outputs? What resources are

used in producing the outputs and what information is needed to measure the efficient use of resources? [Ref. 10: pp. 460 - 462]

3. Strategies for Determining Information Requirements

A strategy was defined as an approach for achieving an objective. There are four strategies for determining information requirements:

a. Asking directly
b. Deriving from an existing information system
c. Synthesizing from characteristics of the utilizing system
d. Discovering from experimentation with an evolving information system

a. Asking Directly

In an asking directly strategy, the analyst obtains information requirements from persons in the utilizing system solely by asking them what their requirements are. From a conceptual standpoint, the asking directly strategy assumes that users can structure their problem space and overcome or compensate for biases due to concreteness, recency, small sample size, and unused data. Anchoring by users in formulating responses is assumed to yield satisfactory results. These conditions may hold in very stable systems for which a well-defined structure exists or in systems whose structure is established by law, regulation, or other outside authority. There are a variety of methods for carrying out an asking strategy.

If a pure asking directly strategy is followed, one or more asking methods are used to elicit requirements, and analysis is limited to consistency checks as requirements are documented. the asking methods can also be used in conjunction with other strategies.

b. Deriving from an Existing Information System

Existing information systems with an operational history can be used to derive requirements for a proposed information system for the same type of organization or application. Types of existing information systems that are useful in deriving requirements for future systems are:

- Existing system that will be replaced by the new system
- Existing system in a similar organization
- Propriety system or package
- Descriptions in textbooks, handbooks, industry studies, etc.

With regard to human problem-solving behavior, deriving from an existing information system is an explicit use of anchoring and adjustment. Users and analysts explicitly choose an existing system as an anchoring and adjust the requirements from it. Driving information requirements from an existing information system has also been termed a data analysis approach since the data inputs and outputs of the existing system are the focus of analysis.

If the information system is performing fairly standard operations and providing fairly standard information for stable utilizing systems, the use of an existing system as an anchor is appropriate. In application systems for some well-defined functions such as payroll, data analysis of an existing system can be a useful primary method. In the early application of computers to organizational transaction processing and accounting system, derivation of requirements from the processing performed on the data provided by the existing system was widely used.

Some analysts use data analysis of the existing system as a secondary method for deriving requirements. To avoid being overly influenced by the concreteness of the existing system, they may delay its use until after their primary analysis method has provided an initial set of requirements.

c. Synthesis from Characteristics of the Utilizing System

Information systems provide information services to facilitate the operation of object systems, those that utilize the information. Requirements for information thus stems from the activities of the object system. This suggests that the most logical and complete method for obtaining information requirements is from an analysis of the characteristics of the utilizing system. This approach may overcome biases by providing an analytical structure for the problem space of the user or analysts. The object system analysis is therefore appropriate when the utilizing system is changing or the proposed information system is different from existing patterns (in its content, form, complexity, etc.), so that anchoring on an existing information system or existing observations of information needs will not yield a complete and correct set of requirements.

d. Discovering from Experimentation with an Evolving Information System

Traditional procedures for determining information requirements are designed to establish a complete and correct set of requirements before the information system is designed and built. In a significant percentage of cases, users may not be able to formulate information requirements because they have no existing models on which to base requirements. They may find it difficult to deal in abstract requirements or to visualize new systems. Users may need to anchor on concrete systems from which they can make adjustments.

Another approach to information requirements determination is, therefore, to capture an initial set of requirements and implement an information system to provide those requirements. The system is designed for ease of change. As users employ the system, they request additional requirements. After initial requirements establish an anchor, additional requirements are discovered through use of the system. The general approach has been described as prototyping or heuristic development. [Ref. 10: pp. 480 - 488]

4. Selecting a Strategy for Determining Information Requirements

Four strategies have been described for determining information requirements, with each strategy having a number of methods that may be employed. The selection procedure is contingent on characteristics of the environment in which the determination of requirements is conducted.

The underlying basis for selecting a strategy is uncertainty with respect to the requirements determination processes. The uncertainty is based on four factors: characteristics of the utilizing system, the information system or application, the users, and the analysts.

The approach to selecting an information requirements determination strategy consists of five steps as shown in Figure 3.1. [Ref. 10: p. 489]

The steps represent a series of evaluations to establish a basis for selection. The evaluations are not precise, but do provide guidelines for judgment. The steps are listed as follows.

1) Identify those characteristics of the four elements in the development process that affect uncertainty in the determination of information requirements:
   - Utilizing system
   - Information system or application
   - Users
   - Analysts
2) Evaluate the effect of the characteristics of the four elements in the development process on three process uncertainties:
   - Existence and availability of a set of usable requirements
   - Ability of users to specify requirements
   - Ability of analysts to elicit and evaluate requirements
3) Evaluate the combined effect of the process uncertainties on overall requirements uncertainty.

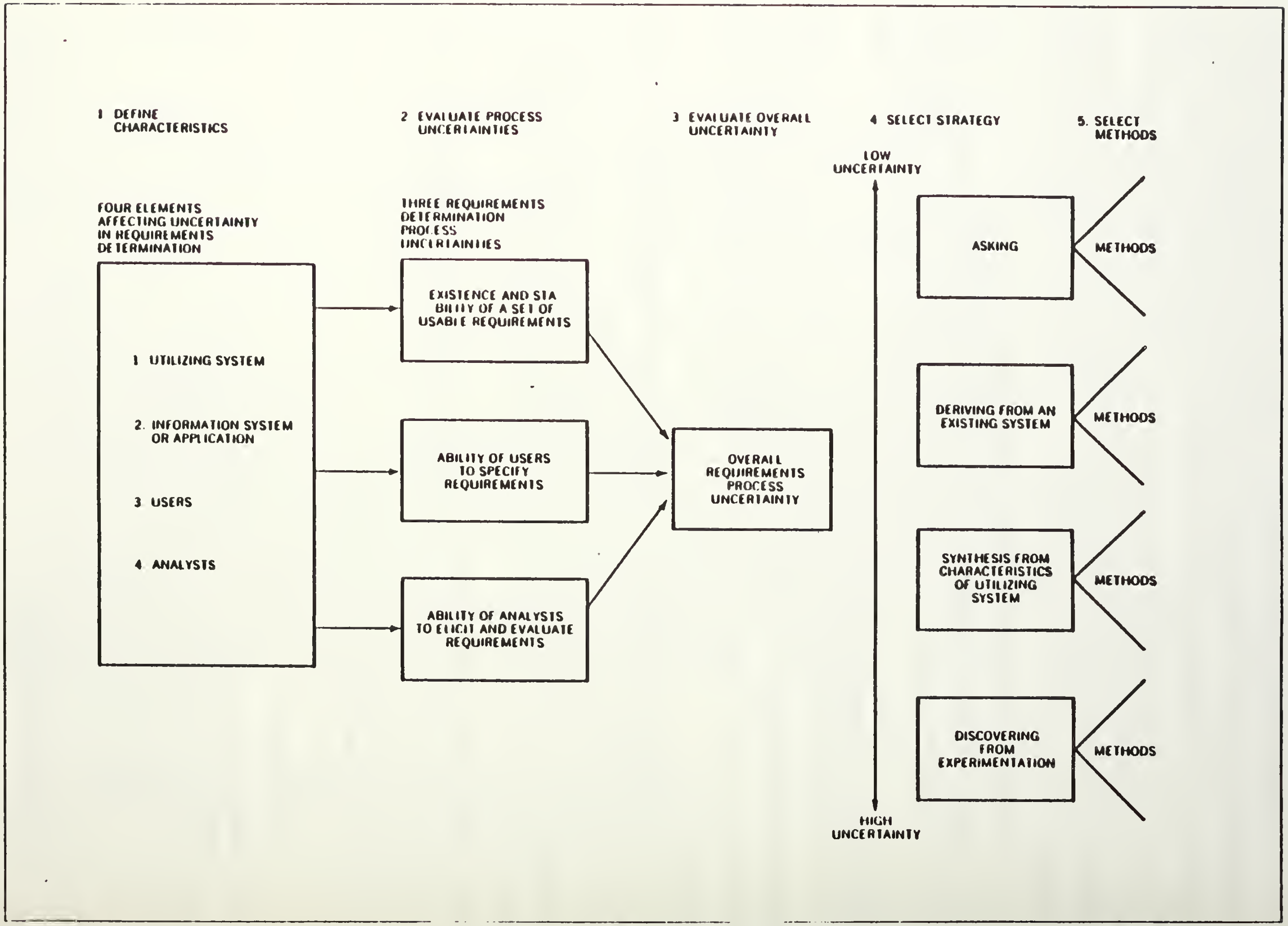

Figure 3.1 Selection of a Strategy.

4) Select a primary strategy for requirements determination based on the overall requirements uncertainty.

5) Select one or more methods from the set of methods to implement the primary strategy. [Ref. 10: p. 490]

B. INFORMATION REQUIREMENTS FOR DRMS OF ROK ARMY DIVISION LEVEL

As we mentioned in the previous chapter, the Defense Budget Revolution Committee was established in order to make an intrinsic improvement in the defense budget system. The committee selected eight major functions to implement the PPBEES system: 1) decision making process; 2) planning programming process; 3) project management system; 4) decentralized management system; 5) computer-based management information system; 6) analysis and evaluation system; 7) resource management staff function; and 8) reorganization.

Among the eight major functions, decentralized management system is considered as the most important and critical function at the army division level. A decentralized management system leads a resource manager (commanding officer) to improve the efficiency and effectiveness of all the resource utilizations and produce various data credibly that high-level units need.

Because management means a boundless decision-making process and the decision making is based on the proper information, a decentralized management system depends heavily upon the quality of management information system of an army division. The information and data are only of use when they are used in decision making. The data gathered without considering the users' needs, evaluation criteria, and decision support models will not provide useful information. While this type of data is "nice-to-know", it is of no use as an aid to analysis or decision making. The information which army division as a resource management unit should produce for its own use and high-level unit's needs may differ according to the type or kind of decision making, that is, different kinds of decision making requires different information.

Decision making may be conducted by rule of thumb from data gathered in the simple cases, but in the more complicated cases a decision support model must be used to get useful information for decision making. Therefore, data gathered should be suitable for the decision support models or data analysis models.

The major premise of the decentralized management system is performance measure. Fair performance major is the best tool to motivate the resource manager of each unit. Resource manager's behaviors may be changed according to the performance criteria (motivation device) that will be decided. Resource managers may operate and lead their unit to be evaluated their performances highly comparing to the established performance criteria. Therefore, in order to determine correct and complete information requirements, decision-making types, decision support models, and performance criteria should be selected before anything else. The analysis of information requirement determination is the most important step in structuring the management information system.

The requirements for routine transaction processing at the army division level might be stable and relatively easy to identify. However, informantion requirements for management and decision making activities would be more changeable and more difficult to define. To identify current and complete information requirements at the army division level, it is rational to survey or interview the various in each functional group: the asking directly strategy is suitable for determining information requirements at the army division level.

1. General Information Requirements

In the previous chapter, we identified the limitations of defense resource management system (DRMS); (1) negligence of operational data that is indispensable for analysis and evaluation system, (2) unsuitable and insufficient data collection methods, and (3) no decision support models. To overcome those limitations of DRMS, the authors try to change the data collection methods based on new information requirements, build the database of DRMS at the army division level, and encourage development of the decision support models in order to meet the initial objective of DRMS.

As mentioned above, the information requirement determination is the critical step. The information requirements must meet the needs of all kinds of decision making, performance measures, decision support models, and existing information systems. In order to meet these needs, we developed general information requirements for the army division level. They are the information requirements that should be accepted in the future to achieve the objective of DRMS at the army division level.

The general information requirements created by authors are listed and explained as follows:

a) Evaluation of each responsible manager's performance.

b) Calculation of the expense of each unit activity.

c) Measurement of each training costs.

d) Derive the expense coefficient of each equipment per operating hour.

e) Accumulate the operating and maintenance cost of each equipment by each model and each production year.

f) Estimation of the life cycle cost of combat urgent equipment.

g) Measurement of the changes in inventory of each unit.

h) Calculation of the logistic support capability.

i) Production of the other data for availability and combat readiness.

a. Evaluation of Responsible manager's performance

To increase the efficiency and effectiveness, each responsible manager's performance is evaluated and compared with the other managers. The performance criteria must be developed to conduct a performance measure of each responsible unit. Information requirements for evaluating each responsible manager's performance must be included in the newly designed database system (called new system below).

b. Calculation of Expenses of Each Unit Activity

This calculation of the expenses of each activity also will provide useful information for commanding officers about how the defense resources should be allocated to maximize the effectiveness of resource utilization in each activity. The expenses of each activity should be collected to two classes; fixed expenses and variable expenses and we must derive the types of relationships among them.

c. Measurement of Each Training Costs

The objective of measurement of each training costs (i.e., petroleum & oil, repair parts, materials, cash etc.) can induce resource managers to consider the cost-benefit analysis of each training. Training cost may differ depending upon the characteristics of each unit and regional conditions. Therefore, the measurement of each training cost will provide a criterion for each unit and each training in budgeting, allocating resources, and forecasting war time minimal resource requirements.

d. Production of the Expense Coefficient of Each Equipment

By using multiple regression technique, we can derive the expense coefficient[3] of each equipment used in different activity or objective. The expense coefficient can become a useful tool for finding out the recording errors in recording the expense of each equipment, a indicator that can shows the differences between each unit and each activity in operating equipments, and a useful criterion for selecting an optimal equipment.

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[3]Expense coefficient is defined as the unit impact of each equipment on defense resources explained in detail in Chapter VI.

e. Measurement of O&M cost of each equipment

One of the important policies in managing the organized equipment is to determine the economic repair limitation and the reasonable retirement time of each equipment. To do these, we need the data about the operating and maintenance costs of each equipment. Although this data may be used at a level higher than the resource management unit, the data must be gathered by the unit that operates the equipment. In the current system, this data is not gathered from the operating units directly and currently not required. But, this data must be gathered from the unit fields and required in the new system.

f. Estimate of LCC of Combat Urgent Equipment

The cost of combat urgent equipment is very expensive relative to other equipment. The estimate of life cycle cost (LCC) of each combat urgent equipment can provide a useful information in measuring the availability or combat readiness, forecasting the demands of combat equipment, and developing the adequate supply package of repair parts in war or peace time.

g. Inventory Management

To increase the efficiency and effectiveness in inventory management, inventory management models (i.e., EOQ: economic order quantity model) should be developed and a systemic device for controlling inventory transaction and finding out changes in inventory should be structured.

h. Calculation of facility maintenance costs

The analysis of facility maintenance costs also give decision makers useful information in planning and budgeting the total facility maintenance costs. We can get the standard maintenance cost per square meter for each facility from analysis of maintenance expenses.

i. Evaluation of Logistic Support Capability

A supply supported unit (army division level) must evaluate the logistic support capability (i.e., stockout items, supply lead time, unused materials, repair parts purchased from the civilian etc.) of the supply supporting unit (logistic command). By doing so, a supply supported unit can take reasonable actions to convert into a rapid supply system and be able to solve anticipated problems in war and peace time.

2. **Output Data List Based on Information Requirements**

Based on the general information requirements, the input data, processing models/software programs, and output formats will be determined. Output documents produced by the new system will be based heavily on the general information requirements and contain the detailed information for decision making. They will be produced by data process associated with materials, cash transaction, and resource utilization in the computer system.

Output documents will be classified into two classes; reports forwarded upward (external documents) and reports used inside (internal documents). External documents are reported to higher echelon, and are used in planning, programming, budgeting, and controlling defense resources. External documents are well developed in the current system as discussed in the previous chapter.

Unfortunately, the current system of internal reporting is underdeveloped. Internal reports generated by the new system consist of useful information with which the commanding officers and staffs can manage the defense resources efficiently.

In this paper, we will place their emphasis on the documents which are utilized within the army division level in order to assess management performance and stewardship, to get information on program activity and fiscal compliance, and to determine resource allocations. Internal documents are created by authors based on the general information requirements discussed above. These documents are listed as shown in Table 3 and are divided into three categories; inflow of resources and changes in inventory, resource utilization, and combat readiness measurement.

3. Specific information requirements

The timely, accurate, and relevant information enable management to evaluate management performance, to determine resource allocation and to make good decisions. To get timely, accurate, and relevant information, the authors defined first the general information requirements and then produced the documents based on them. Now the authors define the specific (detail) information requirements of each document that will satisfy the needs of management.

The authors identify the subcategories of information (data elements) and purpose of each documents in Appendix A.

TABLE 3

NEWLY-CREATED INTERNAL DOCUMENTS

Classification	Document Name
Inflow of resources and changes in inventory	* Unit supply transaction & assets * Total unit resources report * Unit changes in inventory report * Unit resource D / O report
Resource utilization	* Unit activity expense report * Unit resource utilization report * Budget allocation and expenditure * Cash disbursement report * Cash disbursement by activity * Equip. expense coefficient report * Equip. operation by activity * Operating performance by equipment * Unit training cost report * Facility maintenance cost report
Combat readiness measurement	* Combat equipments average life analysis * Supply support required time analysis * Inventory stockout report * Combat urgent equipment and repair part stockout report

C. SUMMARY

Information requirement determination is the starting point in planning an organizational information system, in implementing systems applications, and in building a database. To determine correct and complete information requirements, decision-making types, decision support models, and performance criteria should be selected before determination of information requirements.

Unfortunately, decision-making types and decision support models are not well defined and developed at the ROK Army division level. Therefore, the authors determined the information requirements for DRMS at the army division level based on their judgment and experiences.

The new system which will be redesigned in the future should satisfy the following general information requirements:

- Evaluation of the each responsible manager's performance.
- Calculation of the expense of each unit activity.
- Measurement of the each training costs.
- Derivation of the expense coefficient of each equipment per operating hour.
- Accumulate the operating and maintenance cost of each equipment by each model and each production year.
- Estimation of the life cycle cost of combat urgent equipment.
- Measurement of the changes in inventory of each unit.
- Calculation of the logistic support capability.
- Production of the other data for availability and combat readiness.

Based on the general information requirements, the authors created several internal documents, which will be useful for commanding officers to make decisions. Data contained in those documents can provide the information for the appropriate allocation of defense resources, give performance criteria for performance measure of each unit, and encourage to develop the decision support models.

The next two chapters will discuss the design and manipulation of database that will make it possible to satisfy the information requirements of DRMS at the army division level and to overcome the limitations of current DRMS discussed in the previous chapter.

IV. REVIEW OF RELATIONAL DATA MANAGEMENT APPROACH

A. DATA MANAGEMENT PHILOSOPHY

> Effective management of organizations, both private and public, depends on information concerning the organization's operations, finances, and the allocation of its resources. With such information management can control costs and maximize profits or operational efficiency. Such information also provides a basis for planning for future developments, i.e., new services, improved operations. [Ref. 11: p. 3]

It is widely recognized that data is the most valuable resource in an organization. Since the management of an organization requires a series of decision making activities, accurate and timely data plays a crucial role in making informed decisions. Data must be managed systematically to meet the user's needs; this is the cornerstone of the data management philosophy.

1. Data as a Shared resource

The scope of organizational activities is very broad and associated with the levels of management and functional activities. The most important aspect of management activities is decision-making. Information requirements vary by management level and organizational function, and use common data frequently.

Each functional group could maintain independently the data unique to its decision making, however this might result in data redundancy and inconsistency from a global viewpoint.

The ideal condition is that an organization shares data which is accessible to different users for different purposes. These data might be regarded as the raw material for producing meaningful information. This view supports the notion that information is an organizational resource.

2. Data Independence

The philosophy of data independence is concerned with the aspects of data storage and retrieval. Data independence means the separation of the user view of data (logical data model) from the physical storage of data (physical data model).

When data independence holds, changes in either data model are possible without affecting the other. The database designer or user is allowed to change the storage structure or access strategy in response to changing requirements without having to modifying existing applications.

Data independence is extremely desirable because it potentially increases the applications which can use the same data. If data is dependent on the application (program), we have to separately create and maintain the data used in each case. However, in the case of data independence, different applications can use different views of the same data.

3. Centralized Control

An organization needs to integrate its data processing system with centralized control. If there are no integrating mechanisms, data items may be specified differently and cause inconsistent and incompatible descriptions. There may also be redundant development of separate applications when a single application could serve as well.

Centralized control over an organization's operational data provides several advantages:

- Reduced redundancy
- Consistency of application
- Improved data sharing
- Enforced standards, integrity, and security
- Reduced conflicting requirements [Ref. 12: pp.10-12]

B. DATA BASE MANAGEMENT SYSTEM (DBMS)

Data needs to be managed systematically in order to be available to the user in a timely and accurate manner. A DBMS is a software system which makes the database concept operational.

1. Difference between DBMS and File System

Data base management systems can be distinguished from file systems by the level of functions they provide, as well as the degree of semantics attributed to the data.

a. File system

A file system, as the traditional approach to data, is often characterized by data redundancy and inconsistency.

File systems may also obstruct an organization's growing demands for diverse application programs, because the practice of creating and maintaining separate files for each application tends to store no more data than are needed for the job at hand.

For user access and data integrity, a file system often does not provide adequate conditions. It stores data according to user-defined formats called records, and may or may not provide a directory of files on a per-user basis. Users share data by equally ad hoc means, generally by taking turns accessing the same device.

b. Database Management System

A DBMS provides a higher level of functions than a file system:

- Contains more structured data: maximize accessibility, minimize cost
- Provides a greater degree of data independence from the physical layout
- Supports reliable recovery (back-up) and integrity
- Enables interface with special applications or ad hoc queries

Besides, users interact with the DBMS through language subsets, such as a data definition language and data manipulation language. Most DBMS provide a directory/dictionary at a higher, more user oriented level than file systems do. These details will be discussed in the following section.

2. Functions of DBMS

Since a database management system must ultimately serve the user's needs, the capabilities of DBMS have evolved continuously to provide a significant increase in availability, integrity, and consistency of data. Table 4 lists nine major DBMS functions which were introduced briefly in the previous section.

TABLE 4
FUNCTIONS OF DBMS

- Store, retrieve, and update data
- Provide integrity services
- Control concurrent processing
- Support logical transactions
- Recover from failure
- Provide security facilities
- Interact with communications control programs
- Provide utility services

The DBMS must store, retrieve, and update data. In addition, the DBMS should provide integrity services to enforce constraints on the data.

Maintaining a database with dozens of records and hundreds of data-items can be time consuming. Therefore, the usefulness of the data dictionary is increased if it contains not only data descriptions but also relationships between programs and data, e.g., which programs access which data, and what they do with it.

Since a data base is a shared data resource, several users may try to access it simultaneously. To meet this situation, the DBMS must provide controls over concurrent operations. Actually, concurrent processing is not simultaneous because no two actions take place at the same time in a single CPU or DBMS. The DBMS controls processes which must be interleaved properly in order to preserve the correct data values.

A logical transaction is a sequence of activities performed automatically. Usually, transactions include several actions on the database. However, the DBMS cannot know which groups of actions are logically related. Thus the DBMS must provide facilities for the application program to define transaction boundaries.

The next two functions were already discussed in the previous section on DB requirements. The DBMS must be able to recover from failure, such as machine failures, disk crashes, berserk programs, and unenlightened users. A database is a valuable resource as well as a model of the current state of an organization. If the database is divulged to improper or unauthorized people, considerable damage can occur. To reduce the likelihood of such loss, the DBMS provides security facilities by which users can be defined and identified and authorization enforced.

Additionally, the DBMS must interface with a communications processing system. Terminal users interact with a communications control program, which controls the flow of transactions to application programs which then call upon the DBMS. The final function of utility service is to facilitate database maintenance. People may not follow established procedures, and it may be necessary to determine if one copy of a database is identical to another. Also there may be a need to make mass insertions or deletions of data in or out of the database. [Ref. 13: pp. 401-406]

3. DBMS-related Subsystems

a. Data dictionary/directory system (DD/DS)

The DD/DS provides effective centralized control of organization data resources in a uniform manner.

A data dictionary, as a repository of information about data, represents a description of data stored in the database. The main information contained in the data dictionary includes the following:

- Name of the data item
- A description of the data item
- Source of data
- Impact analysis
- Key words used for categorizing and searching for data item descriptions

[Ref. 10: p. 505]

The directory contains a physical map of the objects it stores ('where' and 'how'), including the external name object, its characteristics, the authorization users have on it, and its relationships with or dependencies on other objects.

The major objective of a DD/DS is to support the integration of metadata[4] in much the same way that a DBMS supports the integration of an organization's data. The benefits achieved from the data dictionary are minimum redundancy, consistency, standardization, and metadata sharing. In addition, the integration of data describing the database allows the database administrator (DBA) to monitor data base content and to effectively enforce security and integrity policies.

b. Database Query Language

Query languages are specific to the database management system with which they are used. Each data base management system has its own query language with unique rules and instruction formats.

Two usages of a data query language are for data processing and reporting applications, and ad hoc queries. The first case is oriented to programmers, such as COBOL, whereas ad hoc queries are sufficiently simple that they can be made by non-programmers.

The most well known query language for relational systems is SQL (structured query language). SQL is a transform-oriented relational language which includes commands for data definition, data manipulation, and data control. In the next chapter, examples of data manipulation using SQL will be presented.

---

[4]Data about the data base: It includes description of the meanings of data items, the way in which the data are used, their sources, their physical characteristics, and other rules or restrictions on their forms or uses.

c. *Database administrator (DBA)*

As database systems come into broader use and organizations gain experience in the use of such systems, the need for controlling the shared data and maintaining the integrity and security of the database becomes obvious. The DBA is assigned the administrative responsibilities that must be centralized as a result of data integration, and the technical responsibilities that are specifically related to the database and use of the database management system.

The DBA is the primary liaison with the users of the data base. The DBA collects and maintains data about the data base and makes this information available to potential data base users. The DBA also maintains specialized software tools needed for data base use, such as data dictionaries, query languages, or design aids. The DBA may provide educational support for database users, on any or all database-related software. [Ref. 12: pp. 15-16]

C. RELATIONAL DBMS

1. Background

Modern database management systems emerged from the mid-1970s. These systems have been developed to overcome the restrictions of previous DB systems and are characterized by interactive access capability. Several users can run different applications concurrently on the same data, and the database system will serialize these data manipulations appropriately.

Trends in current data processing environments, such as the shortage of data processing professionals and the increasing backlog of applications, have motivated the development of database technology. This improves the productivity of data processing professionals by simplifying the database calls in the application programs they write. In addition, it makes it possible for non-DP professionals to specify their queries to an interactive query program and receive their answers on a screen or printer, thereby avoiding the development of an application program altogether.

Relational database management systems manifest the tendency in database technology of providing easy access to data for people who are not data processing professionals as well as those who are. Relational databases provide a very simple, tabular view of data. Unlike the earlier hierarchical and network organizations, relational databases derive relationships from the data values rather than having explicit pointers between records.

2. Relational terminology

Some terminology used frequently in describing relational systems is given below:

- Relation: a two-dimensional table of data; flat files with rows and columns
- Entity: any distinguishable object that is represented in the data base; conceptual representation of the primitive objects
- Attribute: representation of properties of objects; columns of relation
- Tuple: rows of a relation
- Domain: the collection of all values that an attribute can have
- Degree: the number of data items in the record type; number of columns
- Cardinality: the number of rows or tuples in a relation
- Null value: special values representing 'unknown' or 'inapplicable'
- Key: the attribute or attributes with values that are unique within the relation and thus can be used to identify the tuples of that relation
- Relationship: conceptual representation of an association among entities
- Relational schema: a description of the structure of relations in a relational data base
- Relational database: a database that is perceived by the user as a collection of time-varying, normalized relations

3. Relational representation of data

The relational model has the fundamental advantage of conceptual simplicity for a diversity of users in the application environment (casual user, programmer, etc.) who can communicate among themselves on the basis of such a unified framework. A model is the result of the abstraction of an event and is presented by a set of entities and relationships. During the process, relevant attributes of both objects and relationships are chosen and classified into various object types.

Data in the relational model are represented by a relation viewed as a table. The table's heading defines the relation's name, and each row corresponds to an n-tuple of data values describing a single entity. Also, data in each column are assumed to arise from the same domain. A value of a given attribute may change over time, but it always belongs to the domain of that attribute.

An example of the representation of a student entity type by a set of tuples and attributes is shown in Figure 4.1.

NAME	CUR.	SERVICE	SMC
Alice	827	USN	1425
Lee	815	USA	1030
John	837	USN	2123
Kim	817	ROKA	2362
Mary	817	USAF	2551

Figure 4.1 A STUDENT Relation.

STUDENT = (NAME * CUR. * SERVICE * SMC) which represents that each student determines a unique tuple. Each entity can also be shown in Figure 4.2.

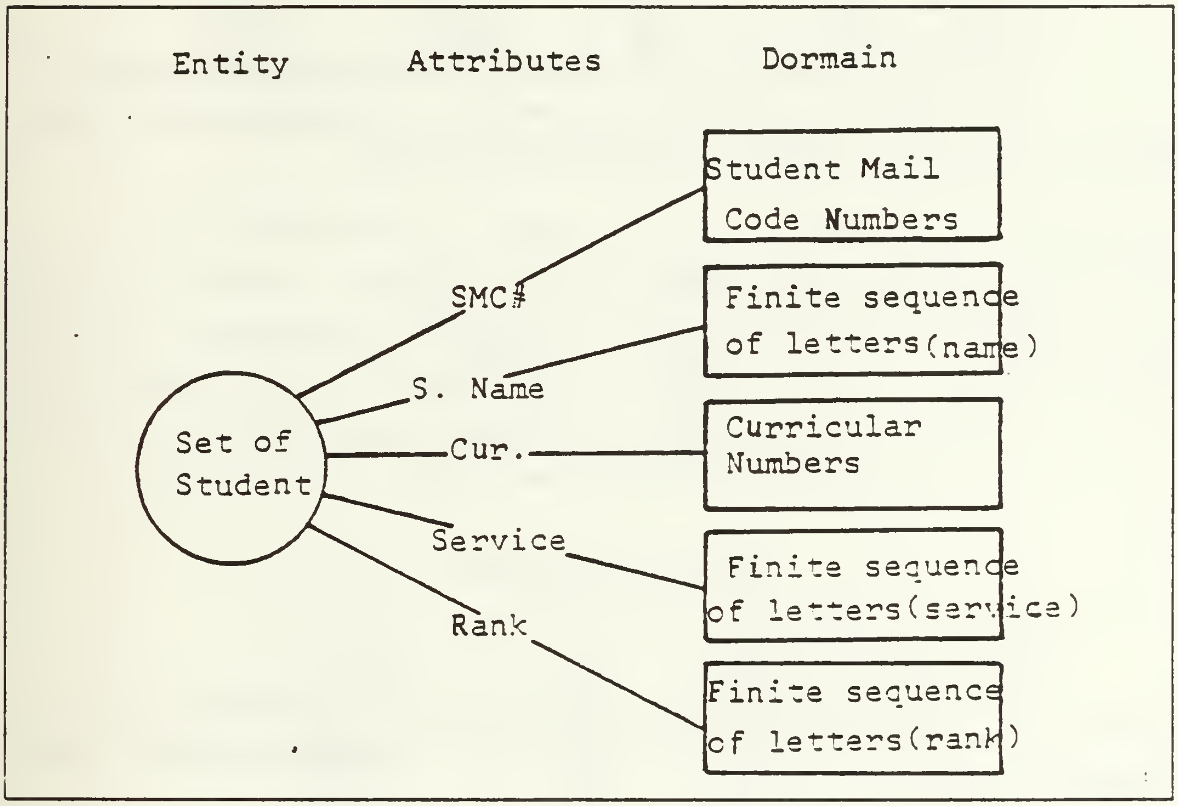

Figure 4.2 Representation of STUDENT entity.

4. **Relational algebra**

As the expression 'algebra' implies, relational algebra is a way of manipulating relations by using a set of operators, such as select, join, projection along with others. Each operation of the relational algebra takes one or more relation(s) as its operand(s) and produces a new relation as the desired output.

Each operation of the relational algebra takes one or more relation(s) as its operand(s) and produces a new relation as the desired output.

The operations are chosen in such a way that all well-known types of queries may be expressed by their composition in a rather straightforward way. The relational algebra includes union, intersection, difference, projection, restriction, join, and division. [Ref. 14: p. 24]

The first four algebra operations are similar to high school algebra, and we can call them the usual set operations. we will define and illustrate the other operations of relational algebra by using the STUDENT relation of the previous section.

a. Projection

Projection is an operation that selects specified attributes from a relation.

Given a relation STUDENT, the projection STUDENT (NAME, CUR.) represents each student's curriculum, as shown in Figure 4.3.

NAME	Cur.
Alice	827
Lee	815
John	837
Kim	817
Mary	817

Figure 4.3 Projection.

b. Restriction (or selection)

The restriction operator takes a horizontal subset and selects tuples to be included in a new relation. The restriction is defined by a logical condition with a rather simple expression.

Given a relation STUDENT, student (Cur. = 817) represents the table of students who are in 'curriculum 817':

c. Join

The join operation is a combination of the product, restriction, and projection operations. We create another relation SERVICE as represented in Figure 4.5.

NAME	CUR.	SERVICE	SMC
Kim	817	ROKA	2362
Mary	817	USAF	2551

Figure 4.4 Restriction.

NAME	SERVICE	RANK	CUR.
Smith	USN	LT	837
Ryan	USN	LCPT	827
Robert	USA	MAJ	817
Kim	ROKA	CPT	817

Figure 4.5 A SERVICE Relation.

Given relations of STUDENT (Name, Cur., Service, Rank, SMC) and SERVICE (Name, Service, Rank, Cur.), STUDENT(Service=Service) SERVICE(Name, Service, Cur.) represents the composition of two operations: the join of the relations STUDENT and SERVICE via the attribute Service, and the projection of the result of the join operation on the attributes Name, Service, and Cur..

The result of the join operation is shown in Figure 4.6.

NAME	SERVICE	CUR.
Alice	USA	815
Robert	USA	817
Lee	USN	815
John	USN	837
Smith	USN	837
Ryan	USN	827
Kim	ROKA	817

Figure 4.6 Join.

5. Relational Query Language

The relational algebra, as a basic means of retrieval of data, is not suitable as a practical query language for casual users of the database because it is too procedural. A number of relational query languages have been developed which are much simpler than the relational algebra in posing queries.

Among the query languages, SQL (structured query language, formerly SEQUEL), developed by IBM, is regarded as the most convenient and powerful. We will use SQL as the query language in all subsequent discussions. SQL is not just a query language, but it permits specification of other actions on the database, including commands for data definition, data manipulation and data control [Ref. 13: p. 265] SQL commands can also be embedded in application programs.

The basic form of SQL is:

SELECT <list of attributes>
FROM <list of relations>
WHERE <qualification expression>

The first two clauses (SELECT, FROM) in the query block define the operation of projection. The qualification expression in the WHERE clause is a logical expression. It contains attributes of relations listed in the FROM clause and determines what tuples of those relations qualify for the operation of projection. This type of nonprocedural database language eliminates the need to specify access paths to the data.

The result of execution of a query block is a relation. Query blocks may appear as operands of the set operations. SQL operations are enumerated as in the Table 5.

TABLE 5
EXECUTION OF QUERY BLOCK

- Projection
- Restriction (selection)
- Join
- Union/difference
- Intersection
- Division
- Insertion/Deletion
- Update

We will present a number of SQL examples using the following schema:

```
STUDENT     (Name, Cur., Smc#)
COURSE      (Course#, Hour, Class room)
SERVICE     (Name, Service, Rank)
PROFESSOR   (Professor, Department, Course#)
```

a. Projection

To obtain a list of students and their curricula:

```
SELECT     Name, Cur.
FROM       STUDENT
```

b. Restriction (selection)

To select all student whose curriculum is '817':

```
SELECT         *
FROM        STUDENT
WHERE       Cur. = 817
```

* denotes selection of all attributes (columns) of the table STUDENT.

To select a table of STUDENTs who have the rank Major or LCDR:

```
SELECT          *
FROM         SERVICE
WHERE        Rank = Major
OR           Rank = LCDR
```

To display the class hours of course# taught by Professor A:

```
SELECT   Hour

FROM     COURSE

WHERE    Course#    IN   SELECT   Course#
                         FROM     PROFESSOR
                         WHERE    Professor = A
```

This example shows how embedding a query from one relation into a query of another permits implicit specification of the natural join operation.

c. Join

This query constructs a table of student's names, curriculum, service, and ranks. As a rather simpler case, this query block is a composition of two operations of relational algebra: projection and join.

```
SELECT    Name, Cur., Service, Rank
```

```
FROM      STUDENT, SERVICE
WHERE     STUDENT Name = SERVICE Name
```

d. Other operations

The ability of SQL query specification ranges far beyond the preceding examples. The other operations shown in Table 5 can also be constructed variations of the examples. Throughout the SQL manipulation, considering the required output relation, the number and domain of the attributes should be well defined to facilitate the future operation.

D. SUMMARY

This chapter provided a conceptual overview of database management systems and relational data management technology. Since the availability of timely and accurate data is the key in any organizational activity, demand for a well-developed database is very high. The data management philosophy gives a rationale for database systems.

A database system, as a mechanized and controlled data pool, provides many advantages that are not available in previous file systems: reduced redundancy; easy application; program-to-data independence; ad hoc query; integrity; security.

A database management system (DBMS) is a set of software making the physical storage of data operational. A data dictionary/directory system, query languages, and database administration (DBA) are the major elements of the system.

The relational database model is the most popular database technology in use today. Its flexible and powerful capabilities enable ordinary users to perform many queries using the relational query language. Some basic examples of SQL operations were introduced to illustrate relational concepts. In the next chapter, we will apply relational database technology to the resource management system.

V. DATABASE APPLICATION CAPABILITY

Based on the information requirements for resource management identified in Chapter III, we will show a basic application of relational database technology. First we develop a logical design for the defense resource management environment, then derive the relations to be processed in the relational database, and finally illustrate the data manipulation required to generate an output (creation of new relation). We use the SQL data manipulation language introduced in the previous chapter.

A. APPLICATION ENVIRONMENT

1. Conceptual Issues

A relational database is a set of relations (tables) whose structure is specified in the schema. The actual sets of tuples change over time due to various actions which are activated by the users in the application environment to reflect the changes that happen over time in that environment. However, only those changes (updates) of the relational database are accepted which perform in accordance with the integrity constraints. Users satisfy their information needs either by triggering prespecified transactions which represent composite queries and produce appropriate reports, or by stating ad hoc queries using user-friendly relational query languages.

The activities in resource management are very complex and multi-faceted. The information required to make a sound decision for the optimal allocation of resources and to produce various analysis for future budgeting must be selected carefully through systematic data processing procedures. This implies two principal aspects of the data base design:

(a) Which data should be collected and maintained in the database?

(b) How can the required information be generated by users?

Since we are dealing with the relational database model, the system should be developed to meet user's needs from the initial stage of relational design in order to maximize its flexibility for answering various queries. The designer must also establish priorities and make the best possible compromise in light of conflicting factors such as elimination of anomalies, relation independence, and ease of use [Ref. 13: pp.307-311].

2. Prerequisite of relational database development

In order to develop the resource database system, there are some prerequisites:

- Establish a coding system
- Establish a standard price system
- Define a measurement units for the different classes of resources
- Design a reporting document format

A coding system is a crucial factor for data base processing and requires a considerable effort. All input data are recorded by using predefined codes, and the codes should encompass all resource activities throughout the division. Coding systems help to substantially reduce the amount of data to be stored. We use a preliminary coding system as shown in Appendix B.

The standard price for each equipment/material is used to convert the amount transacted or resources expended into a money value primarily for the purpose of accounting. Identical price levels for an item contribute to consistent management of performance analysis and cost-effectiveness control of the unit.

Since the division has so many kinds of resources with different units of measurement, it would be very confusing and impractical to record the measurement unit every time in the relation. So we need to decide a basic unit for each input data element, which can be configured automatically according to the resource code.

As defined in Chapter II, the single format of the current report, called the Resource Transaction Slip, causes deficiencies in generating some operational data. The new report format should be designed to overcome this problem. It is recommended that the report prepared by the subordinate unit include all the required data items to meet the diverse information requirements and to exploit the advantage of relational DBMS. Considering the multifaceted resource activities and database input format, the redesigned report should be developed separately for each resource class and activity rather than as a single uniform report.

B. LOGICAL MODEL OF THE DRMS

Designing the DBMS for DRMS is divided into two phases: logical and physical design. Before getting into the specific matters of database design, the designer needs to review the environment of the system and the user's information requirements. Through a series of abstraction processes, the designer can identify the relationships of the individual data to be stored. This process is called a logical design. Then, based on the result, the designer builds a physical design, where the logical design is developed into the constraints of particular program and hardware products.

We first provide the outline of data flows along the major activities within the DRMS system, as in Figure 5.1. Since a logical database design is a representation of reality, it will be helpful to understand the system, and further to plot the logical model.

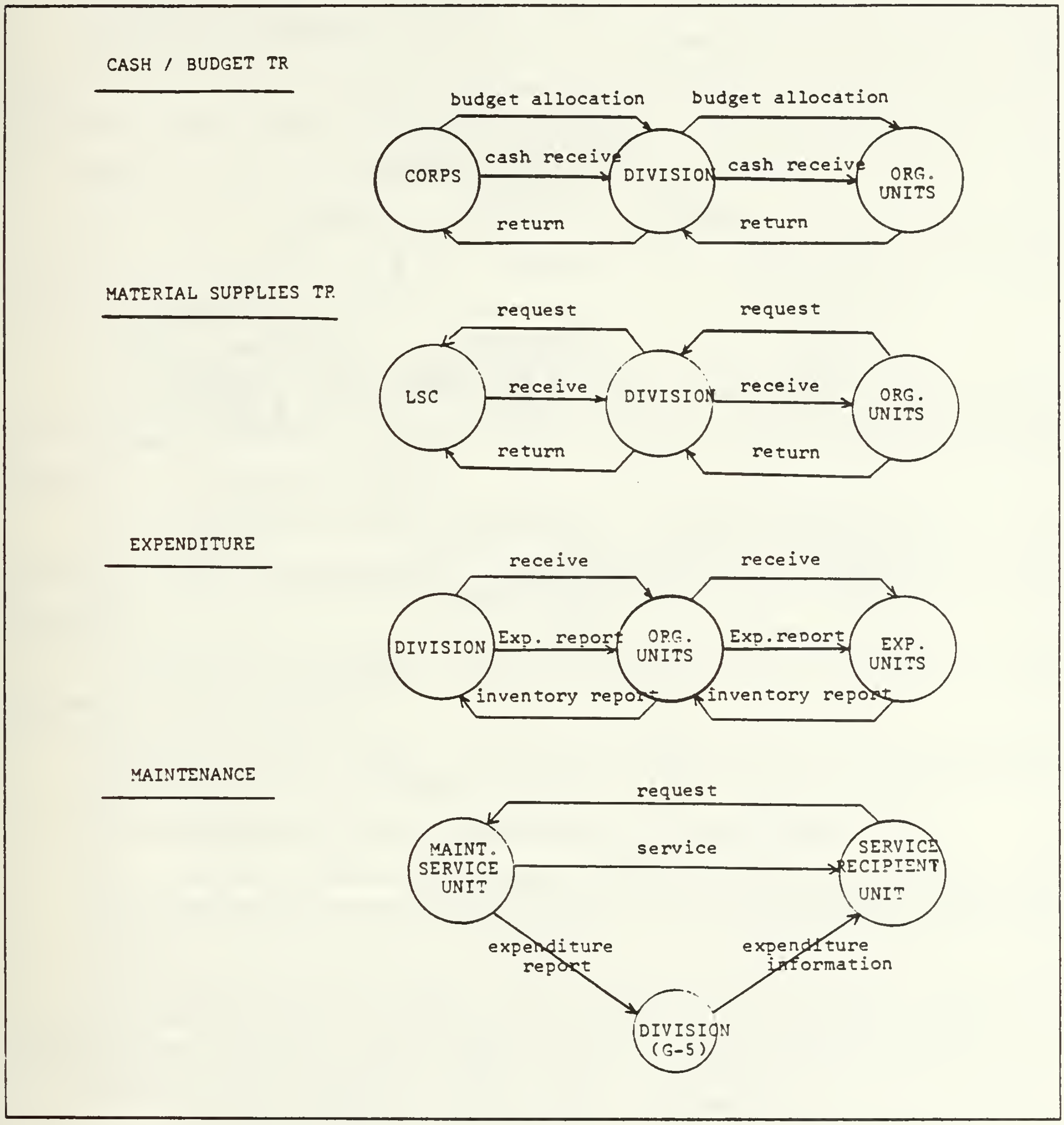

Figure 5.1 Activity Chart of DRMS.

Next, we analyze in more detail the phenomena of the system, focusing on the user's information requirements described in Chapter 3. Throughout the analysis, we try to answer the questions like : 1) what are the prominent objects (entities) of the system?; 2) what aspects of reality are we trying to represent?; 3) what are the relationships between the entities? By answering these questions we can formulate a logical model of the DRMS as shown in Figure 5.2. This logical model provides the conceptual foundation for the following relational representation.

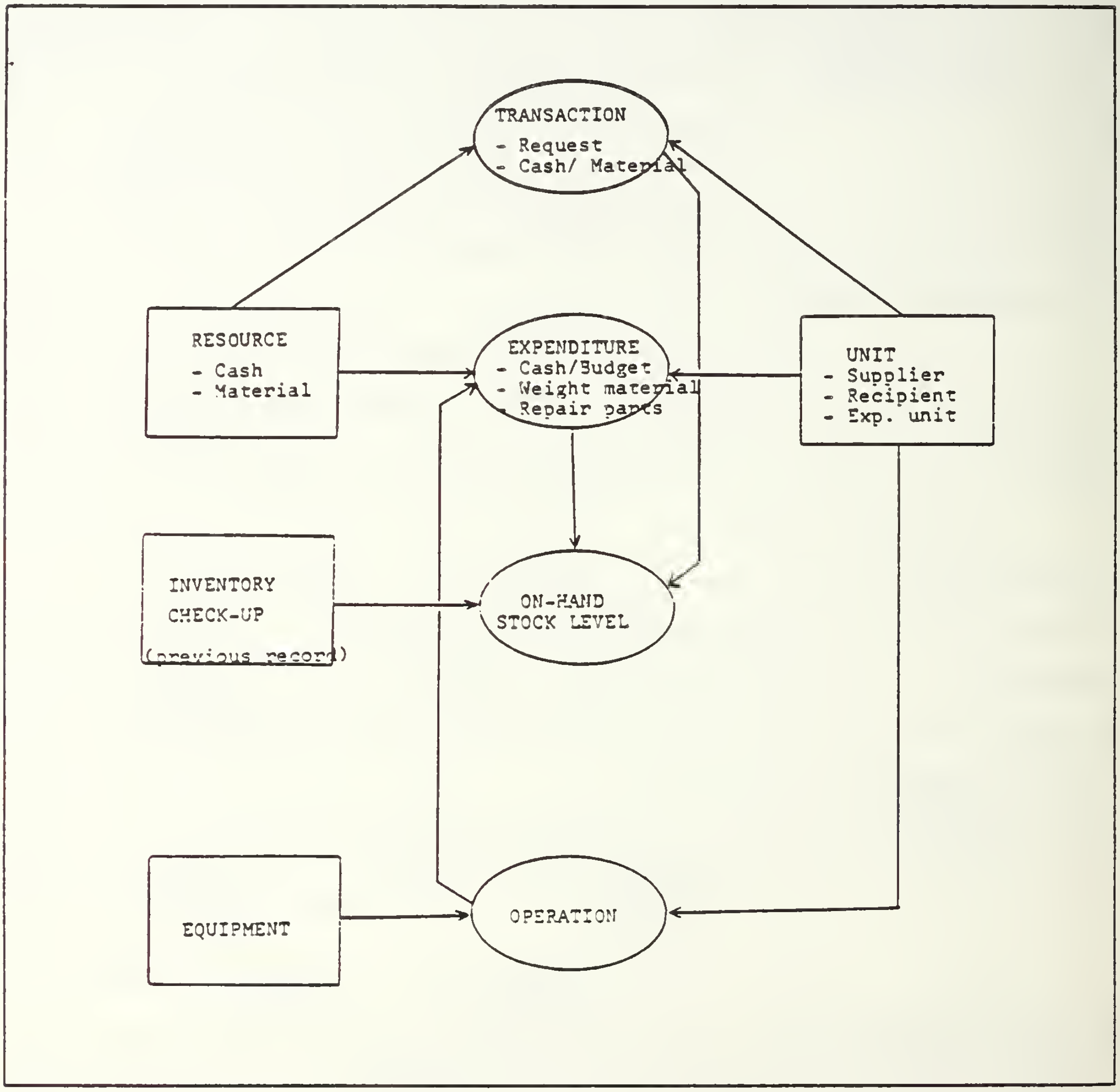

Figure 5.2 Logical model of DRMS.

Entities of the resource management system are represented as squares and relationships shown by circles are named transaction, expenditures, operations, and inventory respectively in the DRMS. A relationship may exist between just two entities or among more entities depending on the activities involved. For example in the case of the EXPENDITURE relation, the expenditure activities are established when a unit uses any resources for certain operational purposes.

C. FORMATION OF A RELATION

A relation can be viewed conceptually as a two-dimensional table that has several properties. Based on the logical model previously defined, each object (entity) or relationship forms a relation, except some objects with a single value (attribute), which are is regarded as the unique characteristics in the military situation.

Now, before representing those relations, in which all the resource activities are recorded and stored as input data for the purpose of future analysis, first let us explain some common attributes of relations.

1. Attributes of relations

A relation is a table which can be processed within the relational database system. When a resource is transacted or expended by the unit(s), this event should be recorded in the appropriate relations.

The issue then becomes what kind of data to include as attributes and how to record them? These considerations are closely associated with the desired output information.

Generally, each relation associated with resource activities should have the following attributes (contents):

- Transaction number (TR#): a serial number given to each transaction activity according to its time sequential occurance.
- Time: time period or date when the resource activities happen
- Unit: the unit (division, regiment, etc.) which assumes the responsible accounting entity. In the case of transaction, units are divided into supplier and recipient.
- Resource: the identified material that is transacted or expended. Materials are sub-classified into individual items within the seven asset groups.
- Stock#: All the government supplied items are given numbers according to the class and characteristics.
- Purpose: Every expenditure is classified as ordinary maintenance; command and staff activities; major mission accomplishment; troop welfare; investment; training and exercises, etc..

- Amount: the number or volume transacted or expended resources. Since the different materials have different units of measurement, we need to decide a uniform rule for the basic unit of each resource-related input data, such as $, kg, gallon, unit, round, etc..
- $value: the money value of the resources transacted or expended. By introducing a standard price system, the whole Army (defense system) can apply identical price levels for each resource item. This is very convenient and helpful in maintaining consistent performance measurement and cost-effectiveness control of the unit.

2. Representation of Relation

An Army division has seven classes of floating assets by and large: (1) cash, (2) food, (3) petroleum, (4) ammunitions, (5) repair parts, (6) individual maintenance material, (7) troop maintenance material. Most of the resource management activities originate from the transaction and expenditures on those resources. Data collection of equipment operations and the determination of inventory level are also important aspects of the DRMS. To cover all activities of the Army division, many different relations will be designed to form a single data pool in the relational database. One of the most important considerations in designing the relations is the elimination of anomalies (insertion, deletion, update). The attributes comprising the key of each relation are displayed in capital letters.

a. Common Entity data

Resource, unit (supplier, recipient, expenditure unit), and equipment are the entities applied to every relation. Units and equipment, however, have only a single attribute and can be identified by unique code numbers (refer to Appendix A).

Resources can be classified into two groups according to their usage characteristics: budget/cash, supplies material (weight material). So they are represented in different relations like Figures 5.3 and 5.4.

(1) *Budget relation.*

BUDGET#	Exp. item#	Amount

Figure 5.3 BUDGET relation.

RESOURCE#	Stock#	Price

Figure 5.4 RESOURCE relation.

b. Transaction Data

The transaction activities are divided into three parts according to their characteristics: (a) supplies request, (b) cash/budget transactions, (c) supplies (material/equipment) transactions.

(1) *Request relation.* The REQUEST relation consists of five attributes (request number, time, resource code, requested/canceled amount) as shown in Figure 5.5.

REQUEST#	Time	Resource#	Amount

Figure 5.5 SUPPLIES-REQUEST relation.

(2) *Cash/budget transaction.* Transaction data should be recorded for each occurrence of budget allocation and receipt/transfer of cash. The format for the CASH-TRANSACTION relation is shown in Figure 5.6.

TR#	Time	Issuer	Recipient	Budget#	Amount($)

Figure 5.6 CASH-TRANSACTION relation.

The attribute 'TR#' (transaction code) identifies three cases of transaction and is numbered in a time sequential manner. 'Issuer' indicates the higher level of unit (Corps, Army command) in the case of budget allocation or transfer of cash, while 'recipient' stands for the subordinate organizational unit or functional staff office when there is a transfer of cash. 'Budget code' is for the detailed budget item from the chapter through subitems. 'Expense item code' assigns the specific item where the budget/cash should be expended. The detailed contents of the attribute are explained in Appendix A (coding system).

(3) *Supplies Transaction.* Supplies transactions deal with the weight material, namely all the floating assets except cash. The relation shows all the supplies flow activities, such as receipt, issues, and return. As shown in Figure 5.7, the transaction of the weight material which moves in and out of the division can be represented with six attributes.

TR#	Time	Supplier	Recipient	Resource#	Amount

Figure 5.7 SUPPLIES-FLOW relation.

c. Expenditure Data

Detailed data about resource expenditures are very informative in revealing what kind of and how much resources are used for what purpose. Since the lower level of units, such as company, are the major source of the actual data, the division plays the most important role in collecting the various operating data efficiently and in generating reports or desired analyses.

In the previous chapter, we classified the resources into seven floating assets. They have different usage and characteristics, so it is rational to store the data separately in three different relations: cash, weight material, and repair parts.

(1) *Cash expenditure Relation.* This relation includes all the resource activities supported by the cash.

BUDGET#	Unit	Time	Purpose	Facility	Equipment	Amount

Figure 5.8 CASH-EXP relation.

An organizational unit or staff office records the related data when the cash is paid to the subordinate unit or the contractor. The attribute 'facility' or 'equipment' is applicable when the cash is used to maintain or repair either object.

(2) *Material expenditure relation.* This relation records expenditure activities of weight material without repair parts, namely five resource classes' expenditure. A new tuple is added periodically or at the time of a major event by summing the amount of consumption for each unit.

RESOURCE#	UNIT	TIME	PURPOSE	EQUIPMENT	Facility	Amount

Figure 5.9 MATERIAL-EXP relation.

(3) *Repair parts Relation.* Considering the unique characteristics of the maintenance activity (refer to Figure 5.1), the REPAIR-PARTS relation, although similar to MATERIAL-EXP, is prepared separately. For every occurrence of a maintenance job, the unit adds a new tuple to the relation in Figure 5.10 . Based on the cumulative records of repaired or exchanged parts of the equipment, the unit can determine the average life (cost) of the equipment.

RESOURCE#	Unit	TIME	Recipient	EQUIPMENT	Purpose	E/M	Amount

Figure 5.10 REPAIR-PARTS relation.

d. Operational data

The other relations are mainly oriented to the transaction and expenditure activities. Data about the operational performance and the current status of the available resources must also be included. The OPERATIONS and INVENTORY relations are designed to account for these defaulted data.

(1) *Equipment operation relation.* The operational performance data are needed to generate useful information about expense coefficients and performance

analysis. The attribute 'operation' holds the operational performance result of the equipment for a certain period. An example of input data is as follows: 1000 miles (maneuvering equipment); 500 hours (generator).

EQUIPMENT	Unit	TIME	PURPOSE	Operation

Figure 5.11 OPERATIONS relation.

In some cases, the operational data can be obtained from the relations of other functional departments within the relational database system.

(2) *Inventory check-up relation.* While the division maintains the data of transaction/expenditure activities, periodic check-up is recommended to prevent the erroneous estimation of the stock level. Coupled with the transaction and the separate expenditure relation, an inventory check-up relation, as in Figure 5.12, keeps track of the exact amount of resource available to the unit at a specific point of time.

RESOURCE	UNIT	TIME	Amount

Figure 5.12 INVENTORY-CHECK-UP relation.

Each organizational unit of the division is required to review its stock level periodically (quarterly or annually), and the data in the relation represents the on hand stock level at the time of physical counting.

D. SQL MANIPULATION

Data stored in a database are valuable only when they are retrieved to meet the user's information requirements through the data manipulation process. SQL is well known as a powerful and flexible data manipulation language and is becoming a standard for relational DBMS. Now we illustrate a set of SQL operations for three examples using simulated data for the purpose of illustration.

1. Case I: Information for Expense Coefficient

The expense coefficient is used as the basis for estimating the standard cost in operating a piece of equipment. To produce a reliable expense coefficient, the regression method is commonly used. The required information includes any data influencing the total expense which can subsequently be used as possible variables of the regression equation.

Here we take the example of a 1/4 ton jeep, as typical equipment applicable to all units. The first thing to do is to get the resource expenditure data and the operational data for certain operational conditions. We show the data manipulation via an actual SQL operation, given the data in Figure 5.13, Figure 5.14, Figure 5.15, and Figure 5.16.

Resource#	Unit	Time	Purpose	Equipment	Facility	Amount
1503	3100	870115	31	11010300		48,000
1503	3300	870115	31	11010300		51,600
1510	4200	870115	31	13010520		76
3301	3100	870115	10	31012010		300
3301	3100	870115	20	31012010		610
3301	3100	870115	31	31012010		425
3301	3200	870115	10	31012020		240
3301	3200	870115	20	31012020		630
3301	3300	870115	10	31012030		230
3301	3300	870115	20	31012030		400
3301	3300	870115	31	31012030		280
3301	4100	870115	10	31012040		410
3301	4100	870115	20	31012040		950
3301	4200	870115	10	31012050		360
3301	4200	870115	20	31012050		475
3301	4200	870115	31	31012050		310
3302	4200	870115	31	31050520		430
1503	3200	870130	31	11010300		49,200
1503	4100	870130	31	11011300		32,000
1510	4100	870130	31	13010510		72
3301	3100	870130	10	31012010		350
3301	3100	870130	20	31012010		470
3301	3200	870130	10	31012020		260
3301	3200	870130	20	31012020		575
3301	3200	870130	31	31012020		450
3301	3300	870130	10	31012030		195
3301	3300	870130	20	31012030		420
3301	4100	870130	10	31012040		470
3301	4100	870130	20	31012040		1,110
3301	4100	870130	31	31012040		360
3301	4200	870130	10	31012050		390
3301	4200	870130	20	31012050		680
3302	4100	870130	31	31050510		520

Figure 5.13 MATERIAL-EXP relation.

Resource#	Unit	Time	Recipient	Equipment	Purpose	E/M	Amount
1411	3100	870115	3110	11010300	31	I	3
3412	3100	870115	3110	31012010	10	I	2
3415	6100	870115	3200	31012020	10	II	1
3416	3200	870115	3230	31012020	20	I	1
3417	4100	870115	4110	31012040	10	I	2
3419	4200	870115	4220	32012050	10	I	5
3451	6100	870115	4200	31050520	31	II	3
1411	3200	870130	3230	11010300	31	I	5
1458	0300	870130	4100	13010510	31	III	1
3411	3100	870130	3120	31012010	20	I	2
3412	3200	870130	3210	31012020	31	I	2
3415	3300	870130	3330	31012030	20	I	2
3415	4100	870130	4120	31012040	20	I	2
3417	4100	870130	4130	31012040	31	I	3
3417	4200	871030	4210	31012050	20	I	1
3459	6100	870130	4100	31050510	31	II	2

Figure 5.14 REPAIR-PARTS relation.

Equipment	Unit	Time	Purpose	Operation
31012010	3100	870115	10	560
31012010	3100	870115	20	1,300
31012010	3100	870115	31	500
31012020	3200	870115	10	310
31102020	3200	870115	20	1,900
31012030	3300	870115	10	210
31012030	3300	870115	20	850
31012030	3300	870115	31	300
31012040	4100	870115	10	1,000
31012040	4100	870115	20	2,700
31012050	4200	870115	10	700
31012050	4200	870115	20	1,500
31012050	4200	870115	31	700
31050520	4200	870115	31	450
31012010	3100	870130	10	440
31012010	3100	870130	20	1,700
31012020	3200	870130	10	440
31012020	3200	870130	20	1,600
31012020	3200	870130	31	500
31012030	3300	870130	10	290
31012030	3300	870130	20	1,150
31012040	4100	870130	10	1,200
31012040	4100	870130	20	2,500
31012040	4100	870130	31	600
31012050	4200	870130	10	500
31012050	4200	870130	20	1,300
31050510	4100	870130	31	480

Figure 5.15 OPERATIONS relation.

Resource#	Stock#	Price
1411	1-23-15	10,000
1458	1-23-56	220,000
3301	3-20-05	3,000
3411	3-23-11	75,000
3412	3-23-21	100,000
3415	3-23-52	115,000
3416	3-23-64	75,000
3417	3-23-71	37,000
3419	3-23-93	70,000
3451	3-34-86	150,000
3459	3-34-92	123,000

Figure 5.16 RESOURCE relation.

In order to produce a table of data resource expenditures on 1/4 ton jeeps for different operational conditions, an SQL query block must be designed. This example requires a typically simple query operation with SELECT, FROM, and WHERE working on 4 relations. Basically this query block is a composition of the relational algebra operations of projection and join under one restriction. In other words, relations MATERIAL-EXP and OPERATIONS are joined by attributes Equipment, Purpose, Time, and Unit whereas relations MATERIAL-EXP and RESOURCE are joined by attribute Resource#. A RESOURCE relation is provided to produce a unit money value for each resource expended.

Given the relations described above, we formulate two separate query blocks to facilitate the query operation. Now we illustrate each procedure step by step to reach the final information.

The first query block represents the projection and join operation over the MATERIAL-EXP and OPERATIONS relations as follows:

```
SELECT   MATERIAL-EXP. Equipment, MATERIAL-EXP. Resource#,
         MATERIAL-EXP. Purpose, SUM(Operation), SUM(Amount),
FROM     MATERIAL-EXP, OPERATIONS
WHERE    MATERIAL-EXP. Equipment  IN (31012010, 31012020, 31012030,
         31012040, 31012050)
  AND    MATERIAL-EXP. Equipment = OPERATIONS. Equipment
  AND    MATERIAL-EXP. Purpose = OPERATIONS. Purpose
  AND    MATERIAL-EXP. Time = OPERATIONS. Time
  AND    MATERIAL-EXP. Unit = OPERATIONS. Unit
```

GROUP BY Equipment, Purpose, Time

ORDER BY Equipment

The relation, as in Figure 5.17, resulting from the query shows the amount of resource (3301; gasoline) used for equipment operations (maneuvering mileage) and three operational purposes.

Equipment	Resource	Purpose	Operation	Amount
31012010	3301	10	1,000	650
31012010	3301	20	3,000	1,080
31012010	3301	31	500	425
31012020	3301	10	700	600
31012020	3301	20	3,500	1,205
31012020	3301	31	500	450
31012030	3301	10	500	425
31012030	3301	20	2,000	820
31012030	3301	31	300	280
31012040	3301	10	2,200	890
31012040	3301	20	5,200	2,060
31012040	3301	31	700	360
31012050	3301	10	1,200	750
31012050	3301	20	2,800	1,155
31012050	3301	31	600	310

Figure 5.17 MATERIAL EXPENDITURE ON 1/4 TON JEEP.

The second query block is designed to produce data about the amount and $value of the repair-parts expenditures for each operational purpose, as follows:

SELECT REPAIR-PARTS. Equipment, REPAIR-PARTS. Resource#,
REPAIR-PARTS. Purpose, SUM(Operation), SUM(Amount),
SUM(Amount*Price)

FROM REPAIR-PARTS, OPERATIONS, RESOURCE

WHERE REPAIR-PARTS. Equipment IN (31012010, 31012020, 31012030,
31012040, 31012050)

AND REPAIR-PARTS. Equipment = OPERATIONS. Equipment

AND REPAIR-PARTS. Purpose = OPERATIONS. Purpose

AND REPAIR-PARTS. Time = OPERATIONS. Time

AND REPAIR-PARTS. Unit = OPERATIONS. Unit

AND REPAIR-PARTS. Resource# = RESOURCE. Resource#

GROUP BY Equipment, Resource, Purpose

ORDER BY Equipment

The output data is generated as in Figure 5.18

Equipment	Resource	Purpose	Operation	Amount	$Value
31012010	3412	10	560	2	200,000
31012010	3411	20	1,700	2	150,000
31012020	3412	31	500	2	200,000
31012020	3415	10	310	1	115,000
31012020	3416	20	1,900	1	75,000
31012030	3415	20	1,150	2	230,000
31012040	3415	20	2,500	2	230,000
31012040	3417	10	1,000	2	74,000
31012040	3417	31	600	3	111,000
31012050	3417	20	700	1	37,000
31012050	3419	10	1,300	5	350,000

Figure 5.18 REPAIR PARTS EXPENDITURE ON 1/4 TON JEEP.

Finally, we want to combine the above two tables (Figure 5.17 and 5.18) to get the final information in a single table which explains all resource expenditures on the 1/4 ton jeep according to operational purpose and performance with the S value for the repair parts.

In order to do this, however, we need to restructure the design somewhat. In particular, we combine the two relations MATERIAL-EXP and REPAIR-PARTS into a single base relation as follows:

PHYSICAL-EXP (Type, Resource#, Equipment, Time, Purpose, Unit, Amount, Facility, Recipient, E/M)

Then we can create the tables MATERIAL-EXP and REPAIR-PARTS as views on the general base relation as follows:

```
CREATE VIEW MATERIAL-EXP AS
(SELECT  Resource#, Unit, Time, Purpose, Equipment, Facility, Amount
 FROM    PHYSICAL-EXP
 WHERE   Type = 'ME'

CREATE VIEW REPAIR-PARTS AS
(SELECT  Resource#, Unit, Time, Recipient, Equipment, Purpose, E/M,
         Amount
 FROM    PHYSICAL EXP
 WHERE   Type = 'RP')
```

This allows us to use the SQL commands exactly as above but with the added flexibility of generating the overall expenditure table by substituting PHYSICAL-EXP for MATERIAL-EXP (or REPAIR-PARTS). This will yield the table in Figure 5.19.

Equipment	Resource	Purpose	Operation	Amount	Amt*Price
31012010	3301	10	1,000	650	1,950,000
31012010	3301	20	3,000	1,080	3,240,000
31012010	3301	31	500	425	1,275,000
31012010	3412	10	560	2	200,000
31012010	3411	20	1,700	2	150,000
31012020	3301	10	700	600	1,800,000
31012020	3301	20	3,500	1,205	3,615,000
31012020	3301	31	500	450	1,350,000
31012020	3412	31	500	2	200,000
31012020	3415	10	310	1	115,000
31012020	3416	20	1,900	1	75,000
31012030	3301	10	500	425	1,275,000
31012030	3301	20	2,000	820	2,460,000
31012030	3301	31	300	280	840,000
31012030	3415	20	1,150	2	230,000
31012040	3301	10	2,200	890	2,670,000
31012040	3301	20	5,200	2,060	6,180,000
31012040	3301	31	700	360	1,080,000
31012040	3415	20	2,500	2	230,000
31012040	3417	10	1,000	2	74,000
31012040	3417	31	600	3	111,000
31012050	3301	10	1,200	750	2,250,000
31012050	3301	20	2,800	1,155	3,465,000
31012050	3301	31	600	310	930,000
31012050	3417	20	700	1	37,000
31012050	3419	10	1,300	5	350,000

Figure 5.19 RESOURCE EXPENDITURE ON 1/4 TON JEEP.

2. Case II: Resource expenditure result of an exercise

Data about the resource expenditure of an exercise provides valuable information for budget allocation and for the estimation of minimum wartime resource requirements. Relational database systems can produce the required information with a simple query block.

```
SELECT   Resource#, Unit, SUM(Amount)
FROM     (Associated) RELATIONs
WHERE    Time = (a specific date or period)
  AND    Purpose = Exercise code number
```

By using the same data as in Case I, let us perform an SQL manipulation to determine the amount of resources expended in field exercise identified with Code 31, which occurred during the second half of January 1987:

```
SELECT   Resource#, Unit, SUM(Amount)
FROM     PHYSICAL-EXP
WHERE    Time = 870130
AND      Purpose = 31
```

GROUP BY Resource#, Unit

ORDER BY Resource#

The table resulting from this query is shown in Figure 5.20. Note that by using the PHYSICAL-EXP table in the query, we get both material and repair parts expenditures. If we had desired only material expenditures, for example, we could have generated that table simply by substituting MATERIAL-EXP for PHYSICAL-EXP in the above query.

Resource#	Unit	Amount
1411	3200	5
1458	4100	1
1503	3200	49,200
1503	4100	32,000
1510	4100	72
3301	3200	450
3301	4100	360
3302	4100	520
3412	3200	2
3417	4100	3
3459	4100	2

Figure 5.20 Resource Expenditure in Field Exercise.

We can display this output data in various formats, according to the desired usage of the information. In some cases we might need data only about the total amount of resource expenditure at the division level, while in other cases we might differentiate the amount for each organizational unit. The latter case is mainly used for the purpose of unit performance evaluation, comparing the expenditure amount with its performance results (mission accomplishment). The amount of the resource can also be also converted into a money value by using the 'price' attribute of RESOURCE relation for accounting purposes.

3. Case III: Determination of the Inventory level

The division performs a physical counting of the inventory level periodically and maintains its records for each resource of the unit. However, the current system, without the database facilities, encounters many difficulties in determining the accurate resource level available at a certain point of time. It relies upon many interrelated documents which takes a considerable amount of time.

However, with some simple relational database query operations, we can figure out the exact level of on-hand stock easily. As shown in the logical model previously introduced, the current stock level is determined from 3 sources: inventory check-up, expenditure records, and transaction results.

Now we present an example SQL query which provides the desired information. For the purpose of representation, we suppose that we want to know the ammunition stock level of the 2nd Infantry Regiment at the beginning of February 1987. In order to make the desired data manipulation, we need the SUPPLIES-FLOW and INVENTORY-CHECK-UP relations in addition to the expenditure data from the previous section. Figure 5.21 and Figure 5.22 provide the sample data for these relations.

TR#	Time	Supplier	Recipient	Resource#	Amount
11401	870105	0410	3100	1505	10,000
11402	870110	0410	3200	1505	10,000
11403	870115	0410	3300	1505	10,000
21402	870116	3100	6200	1505	20,000
11405	870120	0410	3200	1503	40,000
11406	870125	6200	4100	1503	25,000
21406	870129	3200	6200	1503	10,000

Figure 5.21 SUPPLIES-FLOW relation.

Resource	Unit	Time	Amount
1503	3100	860615	15,000
1503	3200	860615	23,000
1503	3300	860615	18,000
1503	4100	860615	9,000
1503	4200	860615	8,600
1503	6200	860615	50,000
1503	3100	870110	25,000
1503	3200	870110	30,000
1503	3300	870110	21,000
1503	4100	870110	11,000
1503	4200	870110	9,000
1503	6200	870110	60,000

Figure 5.22 INVENTORY-CHECK-UP relation.

Before getting into the SQL operation, let us explain the logic of the required query in the ordinary algebraic terms:

Current Inventory Level = {(Previous Inventory Level) + (Received Material)} - {(Expended Material) + (Returned Material)}

This information requires four separate query blocks as follows:

(1) Previous Inventory Level:

```
SELECT  Amount
FROM    INVENTORY-CHECK-UP
WHERE   Time = 870110
  AND   Unit = 3200
  AND   Resource# = 1503
```

(2) Received Material:

```
SELECT  SUM(Amount)
FROM    SUPPLIES-FLOW
WHERE   Resource# = 1503
  AND   Recipient = 3200
  AND   Time BETWEEN 870110 AND 870131
```

(3) Expended Material:

```
SELECT  SUM(Amount)
FROM    MATERIAL-EXP
WHERE   Resource# = 1503
  AND   Unit = 3200
  AND   Time BETWEEN 870110 AND 870131
```

(4) Returned Material:

```
SELECT  SUM(Amount)
FROM    SUPPLIES-FLOW
WHERE   Resource# = 1503
  AND   Supplier = 3200
  AND   Time BETWEEN 870110 AND 870131
```

From the above queries we get the resulting amounts of 30,000, 40,000, 10,000, and 49,200 respectively. By using the report generator capability of the database system, we can generate a single value of present stock level as shown in Figure 5.23.

Resource#	Unit	Amount
1503	3200	10,800

Figure 5.23 CURRENT INVENTORY LEVEL.

This kind of query procedure is usually supported by the report generator capability of the database system. Apart from the ad hoc queries, some typical information required frequently can be generated easily with embedded query procedures.

E. DATA BASE ADMINISTRATION

So far we have discussed the application capabilities of a relational database management system. The database system makes possible flexible application of the shared data by various queries. Now we need to pay attention to another aspect of the DRMS: How can we administer the database effectively to satisfy the information requirements without interruption? Given the complex and multifaceted activities of a resource management system, this issue deserves careful consideration.

1. Data Entry

The procedure of data entry should be strictly controlled to insure accuracy and consistency of the data. In order to accomplish this, a position responsible for data entry can be assigned under the director of the resource management department. The frequency of data entry should be divided into two categories: periodic and occasional. The resources expended in the unit's ordinary activities are recorded by the total amount during the period (weekly or monthly). Expenditures on special events, such as field exercise or annual combined operation, are input at the time of resource activity. These two types of data entry are recommended to facilitate future data manipulation associated with a specific event.

2. Database Maintenance

In the course of data base implementation, some actions should be taken to insure the DBMS is serving the users as intended. These include security procedures and database performance monitoring. Unauthorized access and modification of the database can cause serious problems. Especially since the DRMS is dealing with military materials, the disclosure of data about key materials related to combat readiness must be protected. The division needs to install security features carefully designed to minimize unnecessary overclassified materials. In addition, backup procedures are required to protect against hardware failure or disk loss.

The data base must be able to provide the user with a high degree of continuous performance. This performance is based on matching the unit's information requirements with current technology. The database administrator is expected to maintain a systems performance balance among the hardware, software, and applications. If users of the division's DBMS complain about the process time, access procedure, or the application capabilities of the system, mechanisms must be available for the possible resolution of the matter.

3. Data Integrity

Counteracting the advantages of the data base environment is the increased threat resulting from centralized data. Since many applications are performed with the same data, improper editing or inconsistent data handling among the on-line users makes transaction auditing difficult. Furthermore since other applications may continue to access incorrect data, the problem can give rise to a complicated situation.

In order to preserve the database integrity effectively, standards, testing, procedures, and policies should be enforced by responsible authorities [Ref. 11: p. 142] Those procedures enable the DBMS personnel to maintain integrity, detect the problems, and correct them more easily.

4. Advent of a New Position: DBA

The above functions introduced by the database system imply the necessity for new authorities to take comprehensive responsibility for the data base. Previously individual data was controlled by individual departments, but the integration of data shared among groups requires coordination and centralized control among the users.

Nowadays the position of data base administrator (DBA) is common in organizations with database practices. A DBA can be created as a new staff officer in the division. Considering the current organizational structure of the Army division, the DBA may be positioned as in Figure 5.24.

The operation of the DRMS ranges over all the general/functional staffs (departments), however the DBA must control and coordinate the activity of data entry and maintenance. Even though each department may have its own data administrator who is responsible for maintaining the department-related data, the DBA assumes the higher and final responsibility about the administrative and technical tasks. A DBA can be placed under the EDP manager supervised by the G-5 (Resource

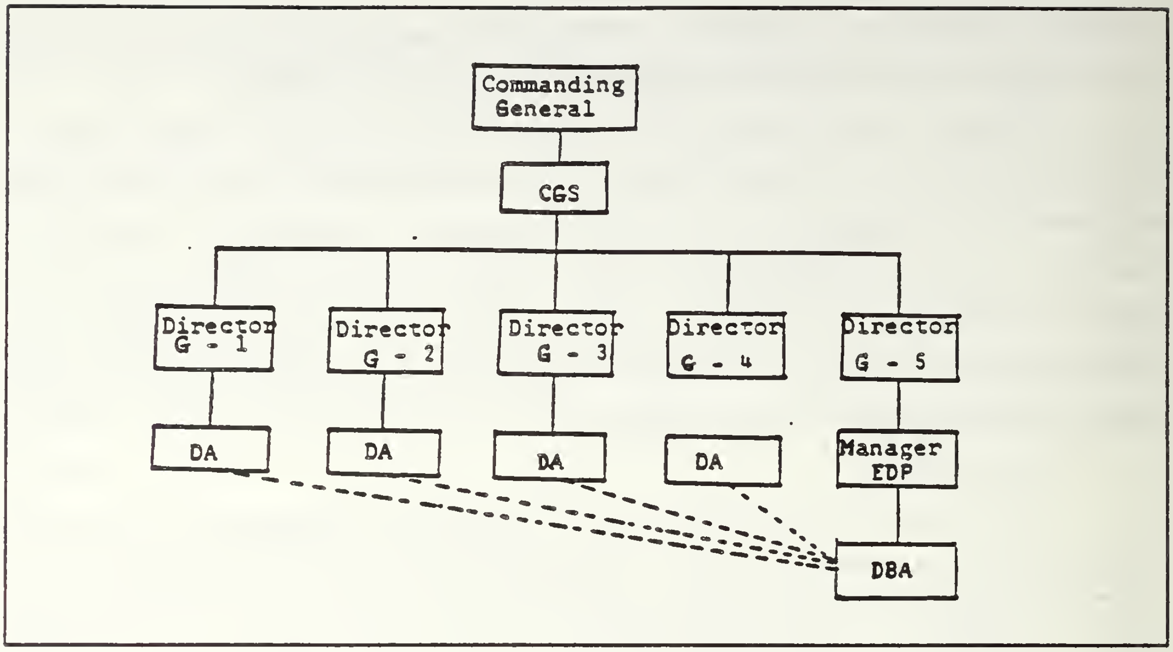

Figure 5.24 DBA of the Army division.

Management Department), because the DBMS is a part of EDP (computer center) group.

F. SUMMARY

The intent of this chapter is to show how a relational database helps the DRMS meet its complicated and diverse information requirements.

This chapter first explained the DRMS environmental issues for which the DB system is supposed to operate. Since the DBMS is a new system compared to the current DRMS file system, we proposed four major factors be developed in order to exploit the advantage of the relational DB system:

- Detailed coding system
- Stand price system
- Measurement unit
- Reporting document format

Following the logical model of the DRMS system, a relational schema was designed similar to an input record format in a file system environment. Designing a relational schema requires elaborate efforts to eliminate various anomalies and to facilitate data manipulation. We created 10 relations to cover all information requirements identified in Chapter III.

SQL operations were illustrated to show the flexible and powerful data manipulation application capability of the relational DBMS. The three sample cases in this chapter demonstrate only a part of the full capability of the system. Once the relational DBMS is established, the user can produce many kinds of information with SQL query operations. The SQL data manipulation language, though relatively simple to use, proves to be a very flexible and powerful tool.

Finally, administrative aspects of the DBMS were briefly discussed: data entry; database maintenance; data integrity. The introduction of DBMS requires corresponding change in the division's information requirements environment. A new position of DBA group was recommended to be responsible for the technical and administrative aspects of the data base.

VI. DATA ANALYSIS AND APPLICATIONS

The objective of defense resource management system (DRMS) is to help commanding officers manage and control the total resources of their units effectively and efficiently, and to enable them to make resonable decisions on the basis of timely, accurate, and relevant information.

To accomplish this objective, up to this point, we have reestablished the information requirements for DRMS and built a suitable database management system in order to obtain meaningful output data easily.

Some information can be directly obtained from the output data. However, to get more accurate and relevant information we must apply some analytical techniques or models. Therefore, in this chapter, we introduce some analytical techniques and models for decision making that can be applicable to the ROK Army division level.

A. REGRESSION MODEL FOR EXPENSE COEFFICIENT

Regression analysis is powerful method of estimation and the most commonly used casual approach to forecasting. It is quite flexible and can include any number of factors in the forecasting models.

Many managerial decisions require predictions or forecasts of future events. These predictions frequently are based on historically observed relationships between variables. These predictions could be made by using regression analysis. This technique is widely used to determine the statistical relationship between two (or more) variables and make predictions of one variables on the basis of the other(s).

1. Simple Linear Regression

In a simple linear regression analysis we attempt to develop a linear model from which the values of a dependent (i.e., response) variable cab be predicted based on particular values of a single independent variable. To develop the model a sample of N independent pairs of observations (X_1, Y_1), (X_2, Y_2), ..., (X_n, Y_n) are obtained, where X_i represents the ith value of the independent or predictor variable X and where Y_i represents the corresponding response - that is, the ith value of the dependent variable Y.

To study the possible underlying relationship between X and Y, the n individual pairs of observations can be plotted on a two-dimensional graph called a scatter diagram. The dependent variable Y is plotted on the vertical axis, while the independent variable X is plotted on the horizontal axis. The scatter diagram aids the researcher in selecting an appropriate regression models. By examining the plotted sample points, the researcher attempts to project the underlying mathematical relationship that may exist between X and Y.

In a simple regression model wherein there is but one predictor variable X, this functional relationship can be expressed as

$$Y = f(X_i) + \varepsilon_i \qquad \text{(eqn 6.1)}$$

where any observed value Y_i in the population would be a function of the true mathematical model $f(X_i)$ plus some residual ε_i. The ε_i term represents scatter above and below the regression equation.

If the scatter diagram indicates a possible linear relationship between X and Y, the population regression model (6.1) can be re-expressed as

$$Y_i = \beta_0 + \beta_1 X_i + \varepsilon_i \qquad \text{(eqn 6.2)}$$

where the two unknown parameters β_0 and β_1 are necessary for determining a straight line. β_0 is the true intercept, a constant factor in the regression model representing the expected or fitted value of Y when X = 0. β_1 is the true slope; it represents the amount that Y changes (either positively or negatively) per unit change in X.

Since we do not have access to the entire population, we cannot compute the parameters β_0 and β_1 and obtain the population regression model. The objective then becomes one of obtaining estimates b_0 (for β_0) and b_1 (for β_1) from the sample. Usually this is accomplished by employing the method of least squares. With this method the statistics b_0 and b_1 are computed from the sample in such a manner that the best possible fit within the constraints of the squares model is achieved. That is, we obtain the linear regression equation

$$Y_i = b_0 + b_1 X_i \qquad \text{(eqn 6.3)}$$

such that $\Sigma\,(Y_i - Y_i) = \Sigma\ \varepsilon^2 i$ is minimized.

2. Multiple Regression Model

In multiple regression at least two independent variables are used to predict the value of a dependent variable. The general form of multiple regression is

$$Y = a + b_1X_1 + b_2X_2 + \dots + b_kX_k$$

The technique for estimating the parameters of the regression equation are similar to those used for simple regressions. A multiple regression model is much more complicated to use than a simple regression model. Generally speaking, the assumptions about the statistical form of the data and the procedures used for assessing the reliability of the estimates are extensions of those associated with simple linear regression.

Estimates of the intercept and regression coefficients are obtained from a set of normal equations, the same as for simple regression, although the normal equations become more complicated and laborious to solve as the number of independent variables increases. Fortunately, computer package for multiple ression model is developed and we can easily get regression equation from computer package.

3. Application of Regression Models

Making a budget for the petroleum or repair parts of a specific model of vehicle, we usually confront some problems; how we should determine the criteria (petroleum consumption ratio per kilometer, repair part consumption ratio per kilometer) for operating the vehicle by 1 kilometer, and how we can determine the fixed amount of their consumption which are not related with the operation of the vehicle. Furthermore, we should take into consideration the activity under given conditions:

- Logistic transportation and administration activity (LOG & ADM)
- Training and military operation activity (TRN & OPT)
- Commanding and staffing activity (CMD & STF)

Different criteria determined depending upon the activities and road conditions are more relevant and accurate than one simple criterion obtained by simple calculation that is used in the current DRMS system.

Assuming that there are 5 same model jeeps in the organizational unit, let's consider two kinds of the expense collecting data format for 5 jeeps. One format as shown in Table 6 is now utilized in the current DRMS system. With this format we can get 0.465 *l / km* by dividing the total amount of petroleum (11,480 ltr) by total operating distance (24,700km).

TABLE 6

CURRENT DATA COLLECTING FORMAT

Jeep No.	Petroleum (ltr)	Repair parts Expense ($)	Operational Distance(km)
1	2,155	350,000	4,500
2	2.255	390,000	4,700
3	1,545	230,000	2,800
4	3,310	415,000	8,100
5	2,215	387,000	4,600
Total	11,480	1,772,000	24,700

On the other hand, if we apply simple regression model with the same data, we can easily obtain a regression equation as follows:

Petroleum consumption per km = 671 + 0.329 x Distance(km).

The result obtained from simple regression model is more accurate and relevant than one obtained by the simple division method. Allocating the petroleum for 10,000 km of operation, we must allocate the petroleum to the organizational unit by 4,650 ltr., if we use the criterion obtained from the simple division method. However, if we use the criterion obtained from simple regression model, we can allocate petroleum to the organizational unit by the only 3,961ltr. (671 + 0.329 x 10,000km). In the simple regression equation, the number 671 means the fixed consumption amount occured not related to the operating activity.

The other data collecting format created in the new DRMS as shown in Table 7 is well improved one for multiple regression model.

TABLE 7
NEW DATA COLLECTING FORMAT

Jeep No.	Petroleum used (ltr.)	Operational Distance (km)		
		LOG & ADM	TRN & OPT	CMD & STF
1	2,155	1,000	500	3,000
2	2,255	700	500	3,500
3	1,545	500	300	2,000
4	3,310	2,200	700	5,200
5	2,215	1,200	600	2,800
TOT	11,480	5,600	2,600	16,500

We can compute the expense coefficient of each activity from data retained in the new format by using computer-aided multiple regression model. We can easily obtain the multiple regression equation by using computer package (MINITAB) as follows:

$$Y = 520 + 0.214X_1 + 0.85X_2 + 0.331X_3$$

Y : Petroleum consumption amount

X_1 : Distance for logistic transportation and administration activity

X_2 : Distance for training and military activity

X_3 : Distance for commanding and staffing activity

In this multiple regression equation, regression coefficients (0.214, 0.85, and 0.331) contain very useful information. They represent the consumption coefficients of each activity. If we get these coefficients, we can forecast the needs of petroleum for certain level of activities with more accuracy and relevance.

For example, if 50,000 km is for logistic and administration activity, 20,000 km is for training and military operation activity, 30,000 km for commanding and staffing activity, then the total amount of petroleum needed in those activities (38,150 ltr.) can be obtained from the above multiple regression equation (520 + 0.214x50,000 + 0.85x20,000 + 0.331x30,000).

In conclusion, simple regression model is better than simple division method, and multiple regression model is the best of the three methods in providing the criteria and equation that indicate influential elements for activities. Therefore, the first data collecting format should be converted to the second format for the new system with a view to obtain more accurate and meaningful information.

B. INPUT-OUTPUT ANALYSIS FOR TOTAL COST

1. General

In this section, we discuss how forecasts can be made using an input-output model.[5] The procedure is presented both in matrix algebra and in words. The theoretical discussion is integrated with a numerical example.

Input-output analysis examines the interrelations existing between components of a system. It does this by specifically accounting for the resource flows that bind the various components of the system into an interdependent whole. The first step in using input-output analysis is to divide the components of the system being modeled into "sectors". A sector represents one organization or function. In the models of the economy, a whole industry - such as steel - becomes one sector. In our model of the ROK Army division, sectors represent functions such as Ground Forces and Army Aviation Unit.

These sectors are, in turn, divided into two groups: those that support other sectors and those that don't. Sectors that support other sectors produce goods and services and, in turn, consume goods and services; such sectors are called processors or

[5]Our procedure describes a static, open model. A static model forecasts each year independently of other years (that is, it does not allow for the dynamic interplay of one year on another). An open model assumes that the output of some activities (called final users) are not measured by the model.

support sectors. Those that don't support others but who do consume the output of the processors, consisting mainly of the operating forces, are called final users: final in the sense that they are the final step in the system.

The resource flows that bind the system together are captured by measuring each sector's output provided to other support sectors and to final users (operating forces). These output measures, or workload indicators, relate changes in the final users to changes in the workloads and the resources consumed by the support sector. It is not necessary that these output measures be actual output. In the work described later, we utilized proxy variables for our output measures. Proxy variables are data which do not directly measure the workload of the support activity but which are assumed to vary roughly in proportion to a direct measure. For example, the actual output of recruit training is trained recruits. Our proxy variable is the number of Army division enlisted men in each sector. The rationale is that on the average the number of trained recruits required by each sector will vary in proportion to the number of men in that sector.

This workload information is then organized into a matrix (called the transactions matrix) which has one row for each processor and as many columns as there are processors and final users. Each row represents the output of that support sector and shows how that sector's output is allocated to each of the consuming sectors, including itself. One sector's output becomes another sector's input so that each entry in a row is an input into the sector represented by the column. Thus, and this is the unique feature of this matrix, each element in the matrix is simultaneously an output of the sector represented by the row and an input to the sector represented by the column. (The name input-output comes from this layout.) In addition, all sectors, both processors and final users, need inputs not only from other sectors within the system, but also inputs from outside the system, such as labor and equipment. These primary inputs can be measured in any appropriate unit and are added to the above relationships by expanding the matrix to include more rows representing the additional inputs.

To illustrate the use of input-output analysis, we have constructed an example utilizing sample data for the ROK Army division level for fiscal year 1987. Table 8 shows the two processors and two final user sectors, their abbreviations used in later tables, the proxy variables for the support sectors, and the primary inputs for this example; Table 9 is the Transaction Matrix. The rows of the upper quadrants of the

Transaction Matrix represent the flow of support from support sectors to both support sectors and final users. The columns of the lower left quadrant are the resources that are inputted to the support sectors for them to generate their total outputs. In this case, the Base Operating Support sector needs 10 units of MP and 230 units of O&M to produce its total output of 60 units (10 + 10 + 20 + 20 = 60).

TABLE 8
SECTORS AND PROXY VARIABLES USED IN SAMPLE PROBLEM

Support Sectors	Proxy Variables
1. Base operating support (BOS)	Military pay (MP), Operations & maintenance (O&M)
2. Logistics (LOG)	Operations & maintenance (O&M)

Final Users Sectors	Primary Inputs
1. Ground Forces (GF)	1. Military personnel (MP)
2. Army Aviation UNit (AAU)	2. Operations & maintenance (O&M)

The Transaction Matrix can be functionally divided into four quadrants as shown in Table 10. The rows of the U and V matrices represent the flow of support from the processors to both processors and final users. The columns of W and Z are the inputs to each sector from outside. Assuming there are m processors, n final users and k resource inputs, U is mXm, V is mXn, W is kXm and Z is kXn. In terms of table 9, the U matrix is a 2 x 2 square matrix, V is a 2 x 2 matrix, W is a 2 x 2 matrix of resource resource inputs, and Z is a 2 x 2 matrix of resource inputs for the final users.

This matrix of inputs and outputs in either dollars or units of real output is just a form of double entry bookkeeping. The usefulness of input-output analysis is that this matrix can be transformed into other matrices which can be manipulated to show structural interdependence and to predict the impact on support of force changes.

TABLE 9

TRANSACTION MATRIX

	Processors		Final User	
	BOS	LOG	GF	AAU
BOS	10	10	20	20
LOG	40	10	20	30
MP	10	10	20	20
O&M	230	260	500	600

TABLE 10

TRANSACTION MATRIX DIVIDED INTO FOUR QUADRANTS

	m columns	n columns
m rows	U	V
k rows	W	Z

2. Transforming Step

Several steps are involved in transforming the subdivided Transactions Matrix into a predicting device.

a. Step 1.

In step 1, each row of U and V is summed to create a column vector, X, of total output.

$$\sum_{j=1}^{m} U_{ij} + \sum^{n} V_{ij} = X_i \qquad i = 1,\ldots,m$$

In this example of Table 9, $X_1 = 60$.

b. Step 2.

Each row of V is summed to create a column vector, Y, representing that part of total output being consumed by the final users.

$$\sum_{j=1}^{n} V_{ij} = Y_i \qquad i = 1,\ldots,m$$

In this example, Y is:

40

50

c. Step 3.

Each element of the jth column of U is divided by the jth element of X to create the mXm matrix A.

$$\frac{U_{ij}}{X_j} = A_{ij} \qquad i = 1,\ldots,m \quad j = 1,\ldots,m$$

Step 3 converts the U matrix, which contains gross data into a matrix of proportional coefficients, commonly called the A matrix. The A matrix is a square matrix with as many rows and columns as there are processors. In words, A is found by first summing across each row; this sum gives the total output of that sector. Then each element in the corresponding column of U is divided by that total. The result, for each support sector, is the number of units of inputs required from each of the sectors including itself for each unit of its output.

For example, column 1 of U from table 9 is:

$$\begin{matrix} 10 \\ 40 \end{matrix}$$

Each element is divided by $X_1 = 60$. These results form column 1 of A which is:

$$10 / 60 = 0.1667$$

$$40 / 60 = 0.6667$$

Table 11 shows the A matrix for our example. The entries in Table 11 are interpreted as follows: 0.6667 (at column 1, row 2) means that for every unit of BOS output, LOG must supply 0.6667 of a unit of its output. Our model is built upon these proportional relationships.

TABLE 11
THIS IS THE (A) MATRIX.

	BOS	LOG
BOS	0.1667	0.1000
LOG	0.6667	0.1000

d. Step 4.

The matrix is subtracted from the identity matrix and then inverted.[6] See Table 12 for the inverse in our example. This inverse matrix $(I - A)^{-1}$ is our forecasting tool. The logic behind its derivation and use can be understood by considering the following series of equation:

$$X = AX + Y$$

$$X - AX = Y$$

$$(I - A)X = Y$$

$$X = (I - A)^{-1}Y$$

e. Step 4.

As before, X is a column vector representing total output from the support establishment and Y is a column vector representing that part of total output being consumed by the final users. AX is column vector representing output consumed by processors.

The $(I - A)^{-1}$ matrix has a very important property; each of its elements r_{ij} shows the total support (as measured by the proxy variables) sector i must provide to enable sector j to provide one unit of its output.[7]

The usefulness of the $(I - A)^{-1}$ matrix is that once it is developed for one set of demands it can be multiplied times a new level of demands by final users (e.g., a new force level), denoted by Y′, to obtain an estimate of the total output requirements from each of the support sectors. Given Y′, the required output, X′, is estimated by:

$$X' = (I - A)^{-1}Y'$$

where

$$Y'_i = \sum_{j=1}^{m} V'_{ij} \qquad i = 1,\ldots,m$$

[6]The inverse of a matrix has the same role in matrix algebra that the reciprocal plays in regular numbers. That is if AX = Y, then X = 1/A or $A^{-1}Y$. The inverse of a matrix is denoted by the same symbol -1.

[7]The inverse matrix $(I - A)^{-1} = I + A + A^2 + A^3 + \ldots$ The expression I + A represents direct support. Each round of support on support is represented by A^n The inverse represents the sum from $n = 0$ to $n = \infty$ of A^n

TABLE 12

THIS IS THE (I - A) INVERSE MATRIX.

$$A = \begin{vmatrix} 0.1667 & 0.1000 \\ 0.6667 & 0.1000 \end{vmatrix}$$

$$I - A = \begin{vmatrix} 1 & 0 \\ 0 & 1 \end{vmatrix} - \begin{vmatrix} 0.1667 & 0.1000 \\ 0.6667 & 0.1000 \end{vmatrix}$$

$$= \begin{vmatrix} 0.8333 & -0.10000 \\ -0.6667 & 0.90000 \end{vmatrix}$$

$$(I - A)^{-1} = \frac{\begin{vmatrix} 0.8333 & -0.1000 \\ -0.6667 & 0.9000 \end{vmatrix}}{(0.8333)(0.9) - (-0.6667)(-0.1)}$$

$$= \begin{vmatrix} 1.3171 & 0.1463 \\ 0.9756 & 1.2195 \end{vmatrix}$$

For example, let's calculate the required total support (X') for next year with a doubled Ground Forces and 5 time Army Aviation Units. We can obtain the required total support of BOS; 212 and the required total output of LOG; 369 as shown in Table 13.

The inverse matrix, $(I - A)^{-1}$, can also be used to estimate the marginal impact of a force change. Defining the force change as Δ Y', then the marginal impact, Δ X', is computed by:

$$\Delta X' = (I - A)^{-1} \Delta Y'$$

f. Step 5.

The resources required to produce the new output, X', must now be calculated. We assume that all resource requirements vary proportionately to output. Our resource estimates are arrived at in the following way:

TABLE 13

CALCULATION OF THE REQUIRED OUTPUT (X')

$$Y' = \begin{vmatrix} 20x2 & + & 20x5 \\ 20x2 & + & 30x5 \end{vmatrix} = \begin{vmatrix} 140 \\ 190 \end{vmatrix}$$

$$X' = \begin{vmatrix} 1.3171 & 0.1463 \\ 0.9756 & 1.2195 \end{vmatrix} \begin{vmatrix} 140 \\ 190 \end{vmatrix}$$

$$= \begin{vmatrix} 212 \\ 369 \end{vmatrix}$$

Each element in the jth column of W is divided by the jth element of X:

$$\frac{W_{ij}}{Xj} = B_{ij} \qquad \begin{array}{l} i = 1,...,k \\ j = 1,...,m \end{array}$$

In our example, row 1 of W from Table 9 is:

	BOS	LOG
MP	10	10

First element is divided by $X_1 = 60$ and second element is divided by $X_2 = 100$. These results form row 1 of B which is:

$$| 10 / 60 \quad 10 / 100 | = | 0.1667 \quad 0.1000 |$$

The new W (= W′) is calculated by multiplying each element in the jth column of B by the jth element of X′:

$$W_{ij} = B_{ij}X'_j \qquad i = 1,\ldots,k$$
$$j = 1,\ldots,m$$

In the example, W′ is calculated as follows:

$$W' = \begin{vmatrix} 0.1667 & 0.1000 \end{vmatrix} \begin{vmatrix} 212 \\ \\ 369 \end{vmatrix}$$

$$= 72.3$$

72.3 indicates the number of variable support personnel needed next year.

The matrix W′ contains the resource estimates for each support sector for forces contained in Y′. The matrix can contain as much detail about resources as desired. Each desired element becomes a row in B.

The inverse matrix can also be used to allocate support resources to forces (final users). This is done by calculating shadow prices (which can be defined as the cost of all resources used, including those used indirectly, to produce each unit of support output) and multiplying these shadow prices times the units of support output used by each final user.

C. OPTIMAL ALLOCATION OF REPAIR PARTS

The operational availability of equipment is the most important criterion of all the concepts which have developed until now for measuring the material readiness. It is an index of system readiness in a mission environment which combines reliability, maintainability and supportability and probability that an item can perform its intended function when called upon.

Operational availability of field equipment is heavily depended upon the maintainability. A certain level of repair parts must be secured and maintained to meet local needs and keep the desired level of maintainability.

In this section, we want to deal with a hypothetical case in order to determine the accurate repair part level.

1. Background

The ROK Army division aircraft are supported by a large inventory of spare parts that are kept readily available to replace components that fail on the aircraft. Many of the failed components are then taken to local repair activities and fixed. The level of inventory kept at the local activity is directly related to the frequency of failure and the length of time it takes to repair a failed component once it does fail.

2. Data

In order to accurately assess local needs, maintenance data is retained for each component that is repaired locally as shown in Table 14. The data layout provides character data, the failure dates, and the repair dates.

TABLE 14

MAINTENANCE DATA LAYOUT

a. Item identification data
    1) national stock number
    2) component name
    3) application
    4) unit price
b. Item failure date
    1) description
    2) failure date
c. Item repair date
    1) description
    2) repair date

For this case analysis, we are concerned with only two of the many data elements retained: the failure date and the repair date. Dates are maintained in the data file as Julian Dates. Julian dates are four digit numbers that represent the last digit of the year and the numeric order of the day within the year. The following examples may help to make this clear:

Date	Julian date
01 January 1986	6001
02 January 1986	6002
31 January 1986	6031
01 February 1986	6032
25 October 1986	6298
31 December 1986	6365
01 January 1987	7001

Data collected using Julian dates are much simpler to manipulate than using day/month/year.

The data set used actually in this case are listed in Table 15 as Julian dates.

TABLE 15

MAINTENANCE DATA USED IN THE CASE

Failure Date	Repair Date	Failure Date	Repair Date
6304	6310	6316	6317
6323	6325	6325	6328
6314	6315	6302	6307
6316	6322	6302	6305
6307	6312	6316	6317
6302	6307	6321	6322
6321	6325	6301	6303
6321	6321	6312	6313
6329	6333	6303	6306
6312	6318	6313	6319

3. Methodology

To determine the accurate inventory level, however, we are not concerned with the date that a component fails, but rather with the length of time that it is in NOt Ready For Issue (NRFI) status - the length of time between failure and repair. To get a reasonable idea of the typical repair time, it is also necessary to accumulate data over a lengthy period of time, then calculate the Average Repair Turn Around Time (TAT). This allows us to develop a proper inventory at a reasonable cost.

4. **Procedure**

Using the APL programming language, we can determine the accurate inventory level with the following procedures:

1. Finding FIRST FAILURE DATE (FFD)
2. Finding LAST FAILURE DATE (LFD)
3. Calculating ANALYSIS PERIOD (AP).
   - AP = LED - FFD + 1
4. Determining TOTAL FAILURES (TF).
5. Calculating AVERAGE DAILY FAILURES (ADF).
   - ADF = TF / AP
6. Calculating MINIMUM, MAXIMUM, AND AVERAGE TURN AROUND TIME (TAT).
   - TAT = Repair date - Failure date + 1
7. Calculating AVERAGE NUMBER IN REPAIR (RBAR).
   - RBAR = ADF x average TAT
8. Computing POISSON ALLOWANCE.
   - Using RBAR as the parameter of a Poisson distribution, print a table that shows N and the CDF of the distribution P(X < = N). The meaning of this table is that if N components are stocked (in a system without repair capacity constraints), they will provide protection from stockout at a level %.

5. **Solution**

Using a simple APL function, we performed simple calculations on the input data and output the results as shown in Table 16. All the APL program used in this case and its solution are described in detail in Appendix C.

In the Table 16, N indicates the number of components which should be stocked to provide protection from stockout at the protection level. P(X < = N) represents the probability that at most N components are needed. The PROTECTION LEVEL stands for the level at which they will provide protection from stockout if N components are stocked.

To maintain the 100 % protection level, we must secure at least 12 components in this case. If we carry more than 12 components, however, we must

TABLE 16
RESULTS OF ANALYSIS

******* DATA ANALYSIS *******

FIRST FAILURE DATE	:	6301	JULIAN DATES
LAST FAILURE DATE	:	6329	
ANALYSIS PERIOD	:	29	DAYS
TOTAL FAILURE	:	20	UNITS
AVERAGE DAILY FAILURES	:	0.6897	UNITS / DAY
TURN AROUND TIME			
MINIMUM	:	1	DAY
MAXIMUM	:	7	DAYS
AVERAGE	:	4.25	DAYS
MEAN DAILY NUMBER IN REPAIR	:	2.931	UNITS

******* RESULTS OF ANALYSIS *******

POISSON DISTRIUTION TABLE

N	P(X≤N)	PROTECTION LEVEL
0	0.05334	5.334
1	0.2097	20.97
2	0.4388	43.88
3	0.6627	66.27
4	0.8267	82.67
5	0.9229	92.29
6	0.9698	96.98
7	0.9895	98.95
8	0.9967	99.67
9	0.9991	99.91
10	0.9998	99.98
11	0.9999	99.99
12	1	100

accrue additional component costs for keeping the same protection level. Therefore, we should minimize the sum of the component costs and carrying costs by determining the accurate component level.

This analysis can help a resource manager to allocate the number of repair parts which should be stocked to provide protection from stockout at a certain protection level to the organizational unit.

D. SUMMARY

MIS developed in response to the needs of management for accurate, timely, and meaningful data for planning, analyzing, and controlling the organization's activities. Within recent years there has been increasing emphasis placed on helping managers make decisions on the basis of good information. As a result, the decision support model has become an essential subsystem within the framework of MIS.

If a suitable database management system (DBMS) is available, then the decision support model can provide nonroutine information through an ad hoc query facility of the DBMS and sophisticated optimizing techniques and statistical packages can be used to analyze available data and provide feedback capabilities to management.

The implementation of a decision support model requires sophisticated mathematical modeling techniques (e.g., linear programming and statistical forecasting), simulation methods, and high-powered computer support. Recent improvements in technology have made possible the implementation of such models in the U.S. Armed Forces.

However, the automated data processing (ADP) technology in the ROK Army is at a primitive stage. To meet the increasing needs of information for decision making, various decision support models should be developed in the ROK Army division level. Those decision support models help a commanding officer make key decisions and thereby improve the effectiveness of the commanding officer's problem-solving process.

In order to encourage the ROK Army division to develop various decision support models for reasonable decision making, we reestablished the information requirements and built a suitable database in the previous chapters.

In this chapter, we showed three data analysis techniques (regression model, total cost model, and component allocating model), as examples for applications, using data obtained from Chapter V. These data analysis models are usually used for forecasting. Forecasting is an important aid in effective and efficient planning, programming and budgeting and it is an integral part of the decision-making activities of management. A large number of forecasting methods are available to management today. The widespread introduction of computers has made programs readily available for all quantitative forecasting techniques.

To be a leader in military management area, the ROK Army should reevaluate its current situation, try to assimilate advanced technologies, and convert to more effective technology such as a database management system.

VII. CONCLUSION AND RECOMMENDATION

The ROK Army is striving to improve the efficiency and effectiveness of its Defense Resource Management System (DRMS). In order to achieve complete self-defense of ROK in a manner superior to North Korea, the allocation and expenditure of limited defense resources must be accomplished in a well-managed cost-effective manner.

Coupled with the establishment of the Defense Budget Revolution Committee (DBRC) in 1983, the ROK Army has taken a series of steps to enhance the DRMS. The major objective of this attempt was to establish a rational cyclic process of planning, programming, budgeting, execution, and evaluation. This is called called PPBEES. The DBRC selected eight major functional areas to be addressed as the means for implementing the newly introduced budget system: 1) decision making process, 2) planning - programming process, 3) project management system, 4) decentralized management system, 5) analysis and evaluation system, 6) computer-based MIS system, 7) resource management staff function, 8) reorganization.

So far, the ROK Army has seen a considerable improvement since the initial implementation of the DRMS, however it is also recognized that there are still trials and errors due to a lack of experience. In this thesis, we identified several limitations of the current DRMS:

- Emphasis on financial data which ignores operational data
- Unsuitable and insufficient data collection methods
- Deficiencies in the analysis of information requirements
- Inadequate development of data analysis and decision support models

The data base approach is regarded as the most practical method, not only to solve the current problems, but also as a means to further improvement. Since the availability of timely and accurate data about the operations, finance, and resource allocation is the key to the management of an organization, the need for an effective DRMS is increasing. A database system, as a mechanized and controlled data pool, provides many advantages that are not available in the traditional file system. These advantages include: 1) reduced redundancy, 2) data application, 3) program-to-data independence, 4) unpredictable query, 5) data integrity, 6) security.

The relational database model is discussed in this thesis because the model provides very powerful and flexible functions that can be easily applied in the DRMS because of its ability to manage complicated and multi-faceted activities. We showed a basic design of the relational database in a preliminary form , based on the user's information requirements. Since a thorough study of information requirements is essential for database design, we identified the information requirements for generating formal reports and various internal analysis. Then, we determined the input data formats (relations) realizing the importance of data relationships to later data manipulation capability. The designer of a relation should keep in mind the principles of independence, elimination of anomalies, and ease of use. Data values in a relation have relationships with other data values in different relations according to their unique characteristics. In order to retrieve the data stored in a database, a data manipulation language such as SQL is used. The user can obtain required data in a desired format by the simple queries. We used some mock data to demonstrate SQL data manipulation.

The retrieved data from the database can satisfy the user only when they are processed to provide information in the useful form. As an example, consider how raw material is processed to become finished goods and then made available to the customer at a commercial value. We now must adopt the appropriate model which can satisfy the user's information requirements most effectively. In most cases, the applied model is to be selected prior to deciding the kind of data to be stored. In order to maximize the computer-based database system, we must develop models appropriate to our particular circumstances.

The expected contributions to the resource management system from the relational database can be illustrated as follows:

- Accumulation of various operational data for future use
- Improved reliability and consistency of analytical procedures
- Enforced standards, integrity, and security
- Centralized control over the DRMS
- Reduction of the personal workload through office automation
- Easy generation of accurate and timely data
- Improved cooperation between the functional staff departments through data sharing
- Reduced conflicting requirements and redundancy of data

We recommend the establishment of a database system at the division level. Since each ROK Army division is already equipped with the computer mainframe as distributed throughout all the military services, this database system will enhance the overall military MIS system.

In addition to the above recommendation, we propose the implementation of the following actions in order to establish the successful database system:

- Expand and develop the existing coding system so each item has one code number
- Establish a standard pricing system
- Redesign Resource Transaction Slip as previously recommended
- Develop the appropriate analysis models
- Extend the computer system to the company level through a PC terminal network

A well developed data base management system offers solutions for the complicated requirements of the DRMS. Considering the planned reorganization of the resource management staff, the introduction of data base can be the turning point toward the overall improvement of DRMS in the ROK Army.

APPENDIX A
SUBCATEGORIES OF EACH INTERNAL DOCUMENT

1. Unit supply Transaction & Assets

1) SUBCATEGORIES OF INFORMATION:

a Resource class: (7 classes of floating assets; cash, foods, petroleum & oil, ammunitions, repair parts, individual maintenance materials, and group maintenance materials)

b Beginning stock

c Logistic Support Command
- beginning due-in(D/I)
- net request
- receipt
- ending D/I
- return

d Organization unit
- beginning D/I
- net request
- supply
- ending D/I
- return

e Ending stock

f Changes in stock

2) PURPOSE: Checking the supply support amount and measuring the stock.

2. Total Unit Resources

1) SUBCATEGORIES OF INFORMATION:

a Unit Name

b Cash

c Foods

d Petroleum & Oil

e Ammunitions

f Repair Parts

g Individual Materials

h Troop maintenance materials

i Total

2) PURPOSE: Allocating resources

3. Chances in Inventory Report

1) SUBCATEGORIES OF INFORMATION:

a Resource class

b Beginning inventory

c Receipt

d Return

e Availability

f Utilization

g Ending inventory

h Changes in inventory

i Request

j Cancellation of request

k Ending due-out (D/O)

2) PURPOSE: Calculating the supply transactions between organizational unit and division.

4. Unit Resource D / O Report

1) SUBCATEGORIES OF INFORMATION:

a Unit Name

b Foods

c Petroleum & Oil

d Ammunitions

e Repair parts

f Individual maintenance materials

g Troop maintenance materials

h Total

2) PURPOSE: Measuring the D / O of each unit by each resource.

5. Unit Resource Utilization Report

1) SUBCATEGORIES OF INFORMATION:

a Unit Name

b Cash

c Foods

d Petroleum & Oil

e Ammunitions

f Repair parts

g Individual maintenance materials

h Troop maintenance materials

i Total

2) PURPOSE: Comparing the resource utilization of each organizational unit.

6. Unit Activity Expense Report

1) SUBCATEGORIES OF INFORMATION:

a Activity

b Cash

c Foods

d Petroleum & Oil

e Ammunitions

f Repair parts

g Individual maintenance materials

h Troop maintenance materials

i Total Percentage (%)

j Budget

k Expense / Budget (%)

2) PURPOSE: Evaluating the expenses of each activity

7. Budget Allocation and Expenditure

1) SUBCATEGORIES OF INFORMATION:

a Activity

b 1/4 Quarter
- budget
- expenditure
- percentage (%)

c 2/4 Quarter
- budget
- expenditure
- percentage (%)

d 3/4 Quarter
- budget

- expenditure
- percentage (%)

e 4/4 Quarter

- budget
- expenditure
- percentage (%)

f Total

- budget
- expenditure
- percentage (%)

2) PURPOSE: Measuring budget expenditure by each quarter and each activity.

8. Cash Disbursement Report

1) SUBCATEGORIES OF INFORMATION:

a Unit name

b Personnel expenses

c Material expenses

d Maintenance expenses

2) PURPOSE: Calculating cash disbursement by each item.

9. Cash Disbursement by Activity

1) SUBCATEGORIES OF INFORMATION:

a Item

b Basic maintenance expense

c Commanding activity expense

d Mission completion expense

e Fringe benefit & welfare expense

f Capital investment

g Supplementary mission expense

h Total

2) PURPOSE: Calculating cash expenditure by activity.

10. Equipment expense coefficient report

1) SUBCATEGORIES OF INFORMATION:
   a Equipment
   b Operation unit
   c Amount
   d Petroleum & Oil expense
      - fixed expense
      - variable expense
   e Maintenance expense
      - fixed expense
      - variable expense
   f Total
      - fixed expense
      - variable expense

2) PURPOSE: Providing criteria for allocating and budgeting resources.

11. Equipment operation by activity

1) SUBCATEGORIES OF INFORMATION:
   a Equipment
   b Amount
   c Operating performance by activity
      - logistic activity
      - commander & staff activity
      - mission activity
      - welfare activity
      - total
   d Maintenance expense
      - operating expense
      - troop maintenance expense
      - field maintenance expense
      - total

2) PURPOSE: Evaluating the operating performance and maintenance expenses of each equipment.

12. Operating Performance of Each equipment

1) SUBCATEGORIES OF INFORMATION:

a Equipment code

b Cumulative operating performance

c Operating performance by activity

- logistic transportation
- commanding & staffing
- mission completion
- welfare
- total

d maintenance expense

- petroleum & oil
- troop maintenance
- field maintenance
- substitution of repair parts
- total

2) PURPOSE: Evaluating the operating performance and maintenance costs of each equipment.

13. Unit Training Cost Report

1) SUBCATEGORIES OF INFORMATION:

a Type of training

b Length

c # of personnel

d Distance of mobilization

e Equipment

a vehicle

b amounted vehicle

c gunnery

d total

f Resource utilization amount

- petroleum & oil
- ammunitions
- repair parts
- cash

- other
- total

2) PURPOSE: Comparing the resource utilization of organizational unit in training.

14. facility Maintenance Cost Report

1) SUBCATEGORIES OF INFORMATION:
   a Type of facility
   b Amount
   c Size (square meter)
   d Maintenance costs
      - cash budget
      - material budget
      - total
   e Average maintenance cost
      - per amount
      - per area(size)

2) PURPOSE: Analyzing the maintenance costs of each facility.

15. Combat Equipment Average Life Analysis

1) SUBCATEGORIES OF INFORMATION:
   a Combat urgent equipment
   b Amount
   c Combat urgent equipment and parts
      - stock number
      - name
      - unit
      - unit price
   d Total substitution times
      - times
      - cost
   e Average substitutation times
      - times
      - cost
   f Average life (hours)
   g Average life (operation)

2) PURPOSE: Forecasting the demands of combat urgent equipments and repair parts.

16. Supply Support Required Time Analysis

1) SUBCATEGORIES OF INFORMATION:
   a Resource class
   b # of transactions
   c Required Time (day)
      - 0 - 8 days
      - 8 - 15 days
      - 15 - 30 days
      - 30 - 60 days
      - 60 - 90 days
      - 90 - 150 days
      - over 150 days

2) PURPOSE: Analyzing the OST of supply support command.

17. Inventory Stockout Report

1) SUBCATEGORIES OF INFORMATION:
   a Resource class
   b 30 days
      - item
      - money amount
   c 90 days
      - item
      - money amount
   d 180 days
      - item
      - money amount
   e Over 180 days
      - item
      - money amount
   f Total
      - item
      - money amount

2) PURPOSE: measuring the stockout of each resource.

18. Combat Urgent Equipment and Repair Parts Stockout Report

1) SUBCATEGORIES OF INFORMATION:

a Type of materials

b Stock number

c Item name

d Unit

e Unit price Necessity amount needed in combat

f Amount of current stock

g Anticipated receipt amount

h Degree of urgency

i Days of stockout

2) PURPOSE: Measuring the stockout of combat urgent equipments and repair parts.

APPENDIX B
CODING SYSTEM

1. UNIT CODE

A. ***Formation***: 4 digit number

B. ***Description***: Each unit or functional staff office has its own code and is responsible for the resource transaction/expenditure. The code is assigned from the higher level of command through the company level around the division and identifies the chain of command of a unit.

C. ***Structure***

(1) 1st digit: units classified into their basic mission.

- 0: higher echelon of command or adjacent unit
- 1: the division headquarter & headquarters
- 2: functional staff office
- 3: infantry unit
- 4: artillery unit
- 5: combat support unit
- 6: service support unit

(2) 2nd digit: a serial number of the command or organizational unit under the same mission

- 01: army command
- 02: corps
- 03: logistics support command
- 04: adjacent unit (division level)
- 21: personnel staff office
- 22: intelligence
- 23: operations and training
- 24: logistics
- 25: planning
- 26: civilian

(3) 3rd digit: the first subordiate unit of the organizational unit (battalion level)

(4) 4th digit: the second subordiate unit of the organizational unit (company leval)

EX) 0300: logistics support command

3100: 1st infantry regiment

3110: 1st infantry regiment 1st battlion

2. TIME CODE

A. *Formation*: 6 digit number

B. *Description*: the date or time period of resource activity

C. *Structure*

- 1st 2 digit: year
- 2nd 2 digit: month
- 3rd 2 digit: day

EX) 871011: Oct 11, 1987

3. RESOURCE CODE

A. *Formation*: 4 digit number

B. *Description*: All the resources (except cash) following through the division are classified into their own codes one by one, according to their charcteristics.

C. *Structure*

(1) 1st digit: function class

- 1: firing E.
- 2: special weapon
- 3: maneuvering E.
- 4: airplane
- 5: ammunitions
- 6: general equipment
- 7: material I
- 8: medical E.
- 9: material II
- 0: ship

(2) 2nd digit : resource class

- 1: cash
- 2: food
- 3: petroleum & oil
- 4: repair part
- 5: ammunitions
- 6: individual maintenance material
- 7: troop maintenance material

(3) 3,4th digit: subclassification of each resource group(class)

EX) 7301: gasoline

4. EQUIPMENT

A. *Formation*: 8 digit number

B. *Description*: The code ranges the whole equipments of the division and the individual equipment has its own inherent code number. Equipments are differentiated from the other materials bacause they are not consumable and operated semi-permanently.

C. *Structure*

- 1st digit: function class
- 2nd digit: sub-functional classification
- 3rd, 4th digit: applicable equipment
- 5, 6th digit: model number (last 2 digit of the whole number)
- 7, 8th digit: equipment serial number of the unit

EX) 1-3-01-05-01: firing equipment, gunnery, 105mm howitzer, model 5, #2

3-1-01-20-01: maneuvering, general vehicle, 1/4 ton, model 20, #1

3-2-02-02-03: maneuvering, combat vehicle, M46 Tank, model 2, #3

5. FACILITY CODE

A. *Formation*: 3 digit number

B. *Description*: Facility code includes real property (land, building etc.) and the other fixed structures in the unit.

C. *Structure*

(1) 1st digit: facility class (according to the purpose)

- 1: basic maintenance
- 2: training and educational
- 3: tactical
- 4: engineering works
- 5: welfare
- 6: service support
- 7: storage (warehouse, tank)

(2) 2, 3rd digit: subclassification of the facility

6. PURPOSE CODE

A. *Formation*: 2 digit number

B. *Description*: The code indicates the purpose for which resources are expended.

c. *Structure*

(1) 1st digit number

- 1: basic mission activity (administration & supply)
- 2: command and staff activity
- 3: major mission performance (training, operations etc.)
- 4: welfare (medical ....)
- 5: investment (acquisition of equipment, facility and weight material)
- 6: others

(2) 2nd digit: subclassification of each mission activity

EX) 31: training; 20: commanding & staff activity

7. BUDGET CODE

A. *Formation*: 10 digit number

B. *Description*: Classification for the accounting purpose; The current system of 'ROK defense budget item code system' has alreay been developed.

C. *Structure*

- 1st 2 digit: budget chapter(budget class group)
- 2nd 2 digit: budget section (sub-class)
- 3rd 2 digit: budget item (subsub-class)
- 4th 2 digit: budget sub-item
- 5th 2 digit: the lowest budget item

8. TRANSACTION CODE

A. *Formation*: 5 digit number

B. *Description*: The flow of resources in and out of the division; Transactions are identified based on the four factors: item, flow line, objective, and frequency.

C. *Structure*

(1) 1st digit number: Types of transaction

- 1: supply
- 2: return

(2) 2nd digit: resource class (1 throug 7)

(3) 3rd digit: transaction line

- 1: army command ----> division
- 2: corps ----> division

- 3: logistics support command ----> division
- 4: division ----> subordinate organizational unit
- 5: organizational unit ----> division
- 6: division ----> logistics support command

(4) 4, 5th digit: the serial number of transaction over the same item

9. REQUEST CODE

A. ***Formation***: 6 digit number

B. ***Description***: Every occurance of request/cancel for supplies is assigned the time-sequential number.

C. ***Structure***

(1) 1st digit: Request type identification

- 1: request
- 0: request cancellation

(2) 2, 3, 4th digit: Resource class (1 through 7) and sub-class

(3) 5, 6th digit: Request serial number annually given to each resource class (regardless of request or cancellation)

EX) 130105: the 5th request for petroleum (gasoline); 030105: cancellation of 5th request

APPENDIX C

APL PROGRAM FOR THE OPTIMAL ALLOCATION OF REPAIR PARTS

```
     ∇COMP[⎕]∇
     ∇ ID COMP DATES;FAIL;REPAIR
  ⍝  oooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooo
  ⍝  o                                                                    o
  ⍝  o                                                                    o
  ⍝  o                                                                    o
  ⍝  o                                                                    o
  ⍝  o  PURPOSE : WRITING A SIMPLE APL FUNCTION THAT USES INPUT FROM      o
  ⍝  o            DIFFERENT DATA VECTORS, PERFORMS SOME SIMPLE CALCU-     o
  ⍝  -            LATIONS ON THE INPUT DATA,AND OUTPUTS THE RESULTS       -
  ⍝  -            IN A READABLE MANNER.                                   -
  ⍝  -                                                                    -
  ⍝  -  KEY VARIABLE                                                      -
  ⍝  -    ID      : ITEM IDENTIFICATION DATA                              -
  ⍝  o   DATES    : FAILURE AND REPAIR DATE OF COMPONENTS                 o
  ⍝  o    FFD     : FIRST FAILURE DATE OF COMPONENTS                      o
  ⍝  o    LFD     : LAST FAILURE DATE OF COMPONENTS                       o
  ⍝  o    AP      : ANALYSIS PERIOD                                       o
  ⍝  o    ADF     : AVERAGE DAILY FAILURE                                 o
  ⍝  o    TAT     : TURN AROUND TIME                                      o
  ⍝  o   RBAR     : AVERAGE NUMBER IN REPAIR                              o
  ⍝  o                                                                    o
  ⍝  oooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooooo
     N←(⍴DATES)÷2
     FAIL←N↑DATES
     REPAIR←N↓DATES
     ITEM ID
     FAIL COMPUTE REPAIR
     ∇

     ∇COMPUTE[⎕]∇
     ∇ FAIL COMPUTE REPAIR;FFD;LFD;AP;TF;ADF;TAT;MINTAT;MAXTAT;AVETAT;RBAR
      ' '
    ⍝ CALCULATE THE STATISTICS OF INPUT DATA
      ' '
     FFD←⌊/FAIL
     LFD←⌈/FAIL
     AP←(LFD-FFD)+1
     TF←⍴FAIL
     ADF←TF÷AP
      ' '
    ⍝ COMPUTE TURN AROUND TIME , MINIMUM, MAXIMUM, AND AVERAGE OF TAT
      ' '
     TAT←(REPAIR-FAIL)+1
     MINTAT←⌊/TAT
     MAXTAT←⌈/TAT
     AVETAT←(+/TAT)÷TF
      ' '
```

```
⍝ COMPUTE MEAN DAILY NUMBER IN REPAIR
' '
RBAR←ADF×AVETAT
' '
'              ******* DATA ANALYSIS *******'
' '
'FIRST FAILURE DATE              :  ',(⍕FFD),'    JULIAN DATES'
'LAST FAILURE DATE               :  ',(⍕LFD)
'ANALYSIS PERIOD                 :  ',(⍕AP),'      DAYS'
' '
'TOTAL FAILURE                   :  '.(⍕TF).'      UNITS'
'AVERAGE DAILY FAILURES          :  ',(⍕ADF),'  UNITS / DAY'
' '
'TURN AROUND TIME'
' '
'         MINIMUM                :  ',(⍕MINTAT),'        DAY'
'         MAXIMUM                :  ',(⍕MAXTAT),'        DAYS'
'         AVERAGE                :  ',(⍕AVETAT),'    DAYS'
' '
'MEAN DAILY NUMBER IN REPAIR     :  ',(⍕RBAR),'   UNITS'
' '
' '
' '
'            ******* RESULTS OF ANALYSIS *******'
' '
'    POISSON DISTRIUTION TABLE'
' '
'   N           P(X≤N)   PROTECTION LEVEL'
⎕←⍉C←(3,⍴K)⍴K,CDF,100×CDF←+\(*-RBAR)×(RBAR*K)÷!K←0,⍳⌈4×RBAR
' '
'  * N = THE NUMBER OF COMPONENTS WHICH SHOULD BE STOCKED TO PROVIDE'
'        PROTECTION FROM STOCKOUT AT THE PROTECTOION LEVEL.'
' '
'  * P(X≤N) = PROBABILITY THAT AT MOST N COMPONENTS ARE NEEDED.'
' '
'  * PROTECTION LEVEL = THE LEVEL AT WHICH THEY WILL PROVIDE '
'        PROTECTION FROM STOCKOUT IF N COMPONENTS ARE STOCKED,'
∇

∇ITEM[⎕]∇
∇ ITEM ID;NSN;NAME;APPLI;PRICE
' '
' '
'****************  ITEM IDENTIFICATION  ***************** '
' '
'NATIONAL STOCK NUMBER           :  ',⍕NSN←17↑ID
'COMPONENT NAME                  :  ',⍕NAME←24↑18↓ID
'APPLICATION                     :  ',⍕APPLI←8↑42↓ID
'PRICE OF COMPONENT              :  ',(⍕PRICE←7↑50↓ID),'   DOLLARS'
∇
```

```
     ∇ DESCRIBE
[1]    'THIS WORKSPACE CONTAINS THREE FUNCTIONS ( 2 GENERIC FUNCTIONS ) AND'
[2]    'TWO VARIABLES ,WHICH CAN COMPUTE THE STATISTICS OF DATA.'
[3]    ' '
[4]    'FUNCTIONS ARE'
[5]    '                COMP ← TYPE COMPHOW TO SEE HOW TO RUN.   '
[6]    '                ITEM ← GENERIC FUNCTION TO PRINT ITEM IDENTIFICATION.'
[7]    '                COMPUTE ← CALCULATE THE STATISTICS OF DATA.'
[8]    ' '
[9]    'AND IT HAS DATA OF ITEM ID. ,FAILURE AND REPAIR DATES OF TOW'
[10]   'COMPONENTS.'
     ∇

     ∇COMPHOW[⎕]∇
     ∇ COMPHOW
[1]    'THE COMPHOW IS DYADIC FUNCTION THAT REQUIRES TWO INPUT MATRICES THEN'
[2]    'COMPUTE THE STATISTICS OF THEM AND PROVIDE A TABLE THAT SHOWS THE NU'
[3]    'MBER OF COMPONENTS AND CDF OF THE POISSON DISTRIBUTION P(X≤).'
[4]    ' '
[5]    'THE SYNTAX FOR CALLING THE FUNCTION IS :'
[6]    '          ID COMP DATES'
[7]    'WHERE ID IS A ITEM IDENTIFICATION'
[8]    '     DATES IS A ITEM FAILURE DATE AND ITEM REPAIR DATE WHICH JOINED'
[9]    '     WITH ','.'
[10]
     ∇
```

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Thesis
K41451 Kim
c.1 Database approach for resource management at ROK Army division level.