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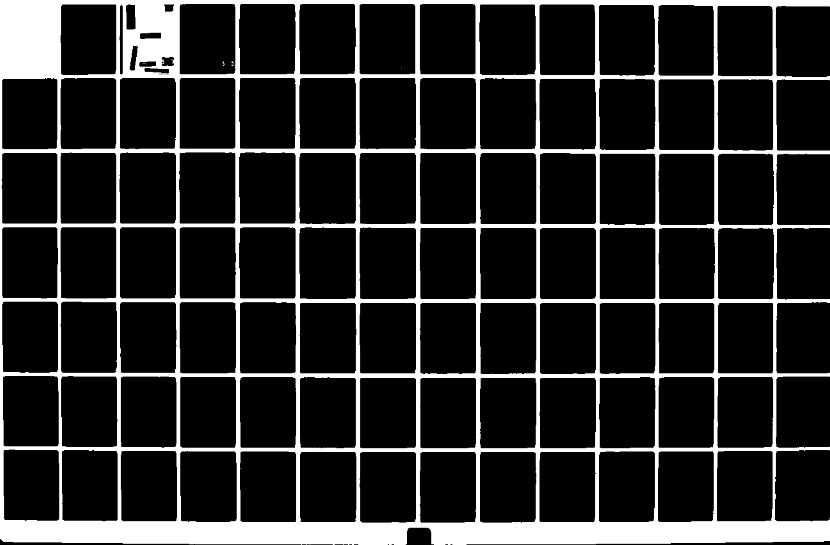

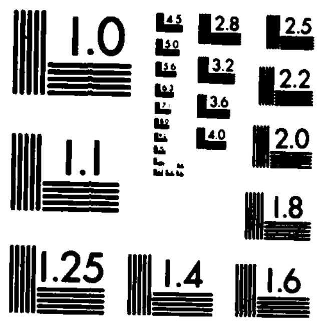

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ANALYSIS OF MILITARY ORGANIZATIONAL EFFECTIVENESS (AMORE)

USER'S HANDBOOK

DECEMBER 1982

Prepared for: U.S. Army *TRADOC Systems Analysis Activity*
WSMR, NM, ATOR-TDA (Mr. Billingsley)

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The purpose of this handbook is to provide user's of the Analysis of Military Organizational Effectiveness (AMORE) methodology with information on the fundamental concepts, the associated computer software, the operational procedures required for its use, and examples and explanations of AMORE methodology applications. The methodology was developed as a means to examine the ability of military units to reconstitute capability as a function of time after experiencing degradation of personnel and/or materiel. In April 1981 SAI published an AMORE User's Manual (ADA 111267) with a companion Programmer's Manual under

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered) contract number MDA-903-C-0409 with Concepts Analysis Agency. The April 1981 User's Manual concentrated on using the AMORE model but did not go into adequate detail on the AMORE methodology. SAI was instructed under this contract to develop an AMORE User's Handbook which used the April 1981 User's Manual as a springboard and expanded the explanations and examples of applying the methodology. The April 1981 Programmer's Manual still applies to the AMORE model.

PREFACE

The purpose of this manual is to provide users of the Analysis of Military ORganizational Effectiveness (AMORE) methodology with information on the fundamental concepts, the associated computer software, and the operational procedures required for its use. The methodology was developed as a means to examine the ability of military units to reconstitute capability as a function of time after experiencing degradation of personnel and/or materiel. This manual is directed toward those users who desire to employ the AMORE methodology as an analysis tool.

This manual has three chapters. Chapter 1 briefly discusses military organizational assessment and the AMORE methodology. Definitions of terms used throughout the manual are included in this Chapter. Chapter 2 addresses the AMORE computer model. It contains the information needed by the organizational analyst to develop input data for the AMORE model. This chapter also discusses the model output. Chapter 3 contains the technical information (card formats, variable names, etc.) needed to enter the input data into a computer.

The methodology discussed in this manual is applicable for use with a number of computer systems. Each computer system has certain unique procedures which must be followed in order to successfully process the AMORE program. The procedures in this manual are directed specifically to the UNIVAC 1100 system and the AMORE model implemented at the Data Processing Field Office (DPFO) computer facility at Ft. Leavenworth, KS.

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CHAPTER 1

THE AMORE METHODOLOGY

1.1 INTRODUCTION

The purpose of the Analysis of Military Organizational Effectiveness (AMORE) methodology is to assess military unit capability as a function of time after suffering losses of assets. The methodology combines in-depth analysis of the unit's functions with a computer model to characterize the response over time of the unit to a simulated attack or other degradation. Not only does the AMORE methodology avoid the pitfalls which plague other methodologies, but it provides an improved measure of effectiveness for military organizations.

Most methods for quantifying unit combat effectiveness rely almost exclusively on attrition counts. These methods determine the number of personnel or items of materiel affected by some degrading mechanism (e.g., conventional or nuclear munitions, peacetime readiness shortfalls) and then use the counts to assess the resultant effectiveness of the unit. Usually, some level of personnel attrition (e.g., thirty percent) is judged adequate to either defeat the target or to result in some level of remaining capability. In some instances, a level of materiel degradation is employed, while in others, both personnel and materiel levels of attrition are recorded and the analyst is usually left with the task of somehow judging what that all means. Even when both materiel and personnel counts are considered together, they are rarely combined logically in a manner which leads to a credible measure of the unit's overall effectiveness.

Furthermore, equating attrition counts with capability levels ignores the fact that unit effectiveness is a function of time. Usually, a military unit can increase capability after attack by reorganizing its remaining resources. Failure to consider unit reconstitution leads to an inaccurate measure of unit effectiveness.

Figure 1-1 shows graphically the inadequacy of using attrition counts to measure effectiveness. In this figure, different unit responses are compared by plotting unit capability as a function of time. Figure 1-1 clearly illustrates that different units inflicted with the same level of damage (attrition count) behave quite differently. Some units are impacted much more than others initially; moreover, different units recover to different levels and do so at quite different rates. The added dimension of the AMORE measure of effectiveness highlights many more facets of a unit's capability. It is clear that the results and conclusions obtained through the use of AMORE will often differ in significant ways from those obtained by simply measuring unit attrition.

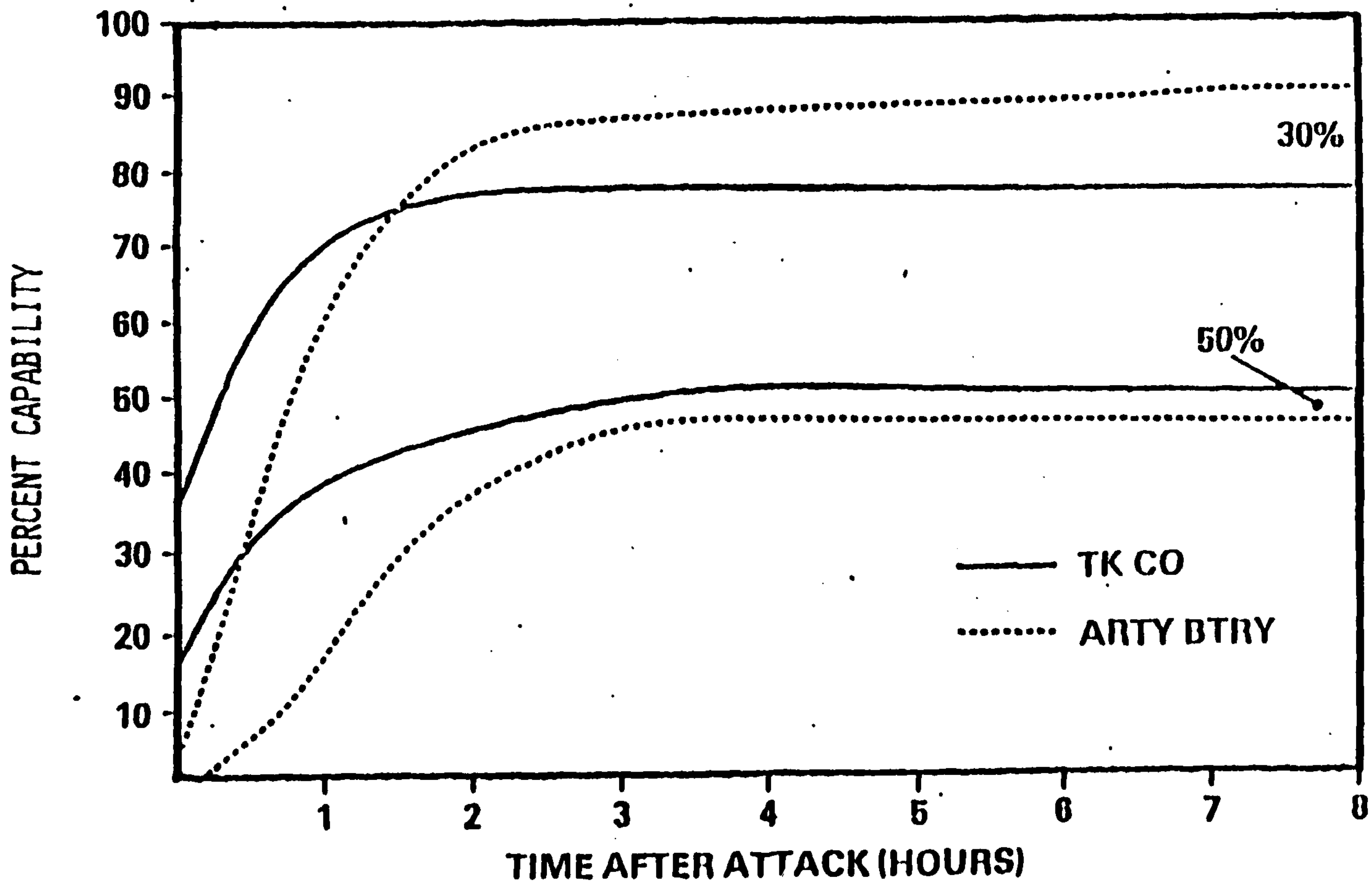
The AMORE approach was conceived and designed specifically to deal with the deficiencies described above. Accordingly, the method possesses the following features:

- Assesses the joint effect of personnel casualties and materiel damage upon the organization.
- Measures effectiveness as a function of time after the initial degradation.

1.2 AMORE METHODOLOGY OVERVIEW

The AMORE methodology provides a detailed analysis of an organization. When using the methodology, organizational analysts study the unit and its missions in order to incorporate both in the measurement of unit capability. The unit capability measurements obtained through the AMORE methodology are realistic measures of

RESPONSE TO SAME LEVEL OF PERSONNEL INCAPACITATION*



*WITH ASSOCIATED EQUIPMENT DAMAGE

Figure 1-1. Unit Response Comparison

effectiveness for organizations which consider the interaction of personnel and equipment over time. The methodology requires identification of the functions which are needed in order to accomplish the mission. Personnel and materiel needed to perform each function are divided into teams. Teams are constructed with the assets needed for various levels of unit operational capability, and thus represent fractions of unit capability. These teams are then reduced to essential teams by stripping them of any people or equipment which are not absolutely necessary for mission accomplishment.

Once the essential teams for the unit and mission under consideration have been established, the unit is degraded and unit reorganization begins. People and equipment who can adequately perform in other jobs (when given time to come up to speed at the task) are reassigned to those jobs so that the unit can quickly come as close to its pre-degradation level of capability as possible. The number of essential teams available to the unit at selected times during the reorganization process provides a measure of capability at those times.

An outline of the AMORE methodology is shown graphically in Figure 1-2. The following text addresses this figure. The box numbers referred to in the text are the numbers in parenthesis in the figure.

The first step in exercising the AMORE methodology is the definition of the mission/posture combination (Box 1). The choice of mission is fundamental to the establishment of essential teams (a result of the functional analysis, Box 2) and the posture is crucial when establishing Probability of Degradation (PD) sets (Box 3). Often in practice, a unit is studied in a variety of mission/posture combinations by use of multiple sets of team requirements and the application of multiple PD sets.

The functional analysis (Box 2) is a detailed study of both the unit TOE (or other organizational representation) and the unit

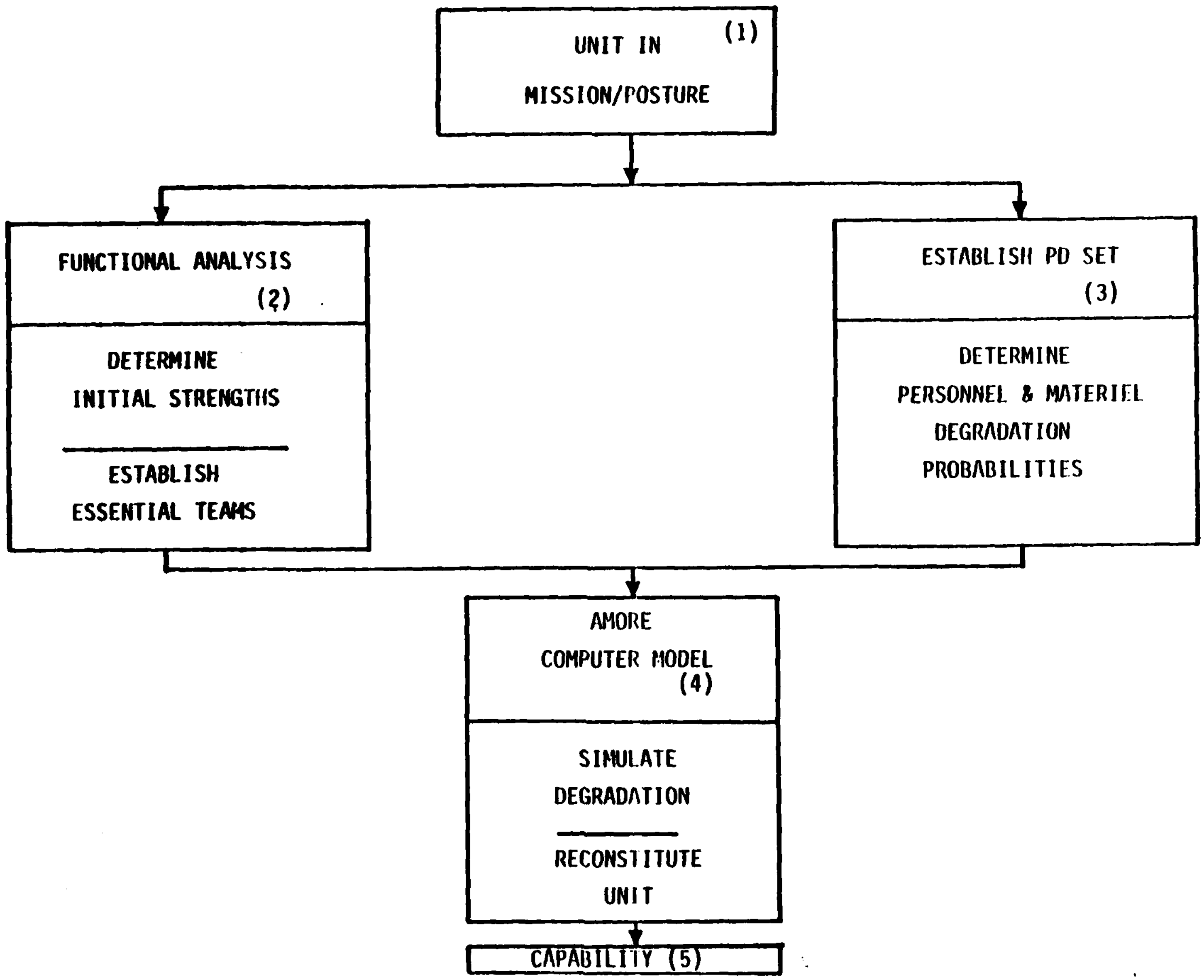


Figure 1-2. AMORE Methodology

mission. Initially, the functions required by the mission are identified and the initial strengths of personnel and materiel required by the TOE are specified. One of the objectives of the functional analysis is to relate the assets of the unit to the functions required by the mission. The assets are then partitioned into teams, i.e., increments of capability, each of which contribute to mission accomplishment.

The analyst must examine each of the teams and establish which of the personnel and equipments in that team are absolutely essential for mission accomplishment. Thus, as a hypothetical example, the crew of an artillery battery might consist of a half-a-dozen personnel, but only four are absolutely essential for combat operation. This minimum complement of personnel serves to define a "bare bones" element. The "bare bones" elements are called essential teams. Note that each essential team is comprised of both personnel and associated items of equipment required to perform some portion of the mission.

Simultaneous with the examination of the organization's anatomy and its dissection into teams is the determination of probabilities of degradation for personnel and materiel (Box 3). The effect of the degrading mechanism on a unit with the assumed mission and posture must be evaluated to determine the personnel and materiel degradation probabilties. These effects may vary between personnel skill groups and equipment types due to inherent differences in personnel postures and equipment vulnerabilities. A variety of methodologies may be used for the evaluation. The universally accepted Joint Munitions Effectiveness Manual (JMEM) methodologies are commonly used to establish probabilities of degradation from simulated attacks. Another commonly used practice is to parametrically analyze degradation of a unit.

This information is input to the AMORE computer model (Box 4). The model simulates both the degradation of the unit (subject to the PD's input) and the post-degradation regrouping of personnel and materiel into the maximum number of essential teams (according to the requirements, Box 2). The degradation is assessed using a Monte Carlo technique and the input probabilities. Regrouping, or reconstitution, requires a knowledge of which of the individuals in the unit can be used or substituted for various skills, and also which items of equipment are substitutable for other items. Further, when substitutions are feasible, one must also consider the time required for a decision to substitute and the time it takes to effect a substitution. In the case of personnel, one must also consider the time it will take a replacement to come up to speed in performing the new task. These and many other pertinent times are all considered so that the gradual build-up of unit effectiveness becomes expressible as a function of time.

The problem of unit reorganization becomes one of making optimal personnel and materiel assignments based on the available substitutions to fulfill the commander's objective. A transportation algorithm is used because of the supply and demand nature of the problem, as well as the requirement that all assignments be integral. Following degradation, some of the teams have lost essential team members and are no longer capable of performing their mission. The number of teams which remain operational is the measure of the unit's initial capability. Increasing capability requires the reorganization and reconstitution of essential teams. Thus, regrouping of personnel and materiel to maximize the number of essential teams is one of the commander's main objectives. Another objective is to minimize the average time required to reach maximum capability.

The teams which are reconstituted in time represent the recovery of capability by the unit. The stochastic processes used by the model necessitate the evaluation of multiple iterations of the process. Results for all iterations are averaged to develop an expected value of unit capability (Box 5) for the defined mission(s) and the simulated degradation. Figure 1-1 is typical of the results obtained, showing unit capability as a function of time, and illustrates the differences of unit types and their response to the same level of degradation.

The AMORE software is designed to provide other information in addition to capability as a function of time. The model will identify those personnel skills and equipment items which precluded additional increases in unit capability. Further, the assignments which were made in order to achieve the capability levels output are tracked and may be output for analysis. Thus, AMORE provides data for an in-depth analysis of the weaknesses, and the strengths, of a unit.

The AMORE methodology provides a measure of an organizations capability considering the organization as a system of both personnel and equipment interacting over time. The methodology is sensitive to:

- Differences in degrading effects
- The specific capabilities of individual personnel and equipment items
- The interaction of the personnel and equipment to form teams which contribute to organizational capability.

1.3 DEFINITION OF TERMS

Assignment Matrices Ref: Sections 2.1.2.4 2.2.4.5 2.3.3.3	An AMORE program option. This option processes and prints assignment matrices, which contain the average over all iterations of the optimal allocation of resources.
Capability Ref: Sections 2.1.1.3 2.3.2.2	Capability is the fraction of total essential teams that a unit is able to reconstitute within some time following degradation. Capability is calculated and output for times specified by input.

Choke Analysis Ref: Sections 2.1.2.2 2.2.4.3 2.3.3.1	An AMORE program option. This option determines the personnel skills and equipment items which would be needed to build more essential teams. It also determines the materiel and personnel surpluses.
Choke Point	A personnel skill or equipment item identified as critical by the Choke Analysis.
Commander's Decision Time	See Decision Time.
Critical Personnel Skill (Equipment Item)	A personnel skill (or equipment item) which would be needed to build another essential team. Critical skills and items are identified in the Choke Analysis.
Decision Time Ref: Section 2.2.3	An AMORE program input. Also called commander's decision time. A delay time imposed upon transfers between personnel skill groups and between equipment types which models the time it takes a commander to assess the condition of the unit and to decide how to reorganize. NOTE: The delay time is not imposed upon transfers within a skill group or equipment type.
Degradation Ref: Section 2.1.1.1	The simulated loss of unit resources.
Equipment Type Ref: Section 2.2.2.3 2.3.2.1	An AMORE program input. A category of unit materiel which contains all equivalent equipment items. (Items within the same equipment type are interchangeable.)
Essential Teams Ref: Section 2.2.2.5 2.3.2.1	An AMORE program input. The breakdown of the unit into components (teams) which contain only the personnel and materiel that are absolutely necessary to mission accomplishment.

Functional Analysis	A detailed study of a unit and mission to identify the functions, skills, and equipment needed to carry out the mission and to determine how the unit actually performs the functions.
Infinite Time Capability	See Maximum Capability.
Initial Capability	An AMORE program output.
Ref: Section 2.1.1.3	Also called zero time capability. The capability immediately after degradation, but before reconstitution of the unit begins.
Initial Strength	An AMORE program input.
Ref: Section 2.2.2.3 2.3.2.1	The pre-degradation inventories of personnel within each personnel skill group and materiel within each equipment type. Initial strengths are the units original supply.
Input Only	An AMORE program option.
Ref. Section 2.1.2.6 2.2.4.7 2.3.3.5	This option causes a listing of the input data to be printed, without any main program processing.
Iteration Ref: Section 2.1.1	A single replication of the AMORE model.
Light Damage	A damage level for equipment.
Ref: Section 2.2.2.3 2.2.3	Light damage can be repaired by the crew. Light damage requires an input PD and repair time for each equipment type.
Line Number Ref: Section 2.2.2.3	The index numbers for the personnel skill groups and the equipment types.
Maximum Capability	An AMORE program output.
Ref: Section 2.1.1.3 2.3.2.2	Also called Infinite Time Capability. Capability when all possible transfers and all possible equipment repairs have been made.

Mean Time Only

Ref: Section 2.1.2.5
2.2.4.6
2.3.3.4

An AMORE program option.

This option allows the user to designate how the input time values (transfer, decision, repair) are to be used. Deterministic - use the times as input. Exponential distribution - use the input times as the mean values of an exponential distribution and draw all time values from that distribution.

Minimum Capability

Ref: Section 2.1.1.3
2.3.2.2

An AMORE program output.

Capability evaluated immediately after the start of the reconstitution. All transfers are in progress, but only those with a total time (transfer + decision + repair) of zero have been completed.

Moderate Damage

Ref: Section 2.2.2.3
2.2.3

A damage level for equipment.

Moderate damage can be repaired by the unit, but not by the crew. Requires an input PD and repair time for each equipment type.

Multiple Optimal Solution (MOS)

Ref: Section 2.1.2.3
2.2.4.4
2.3.3.2

An AMORE program option.

This option provides choke analysis data for multiple optimal solutions. The model is generally exercised without this option and choke analysis data is for the first found optimal solution.

Number of Iteration

Ref: Section 2.1.2.1
2.2.4.2

An AMORE program feature.

This feature allows the user to specify the number of iterations for each AMORE run.

Personnel Skill Group

Ref: Section 2.2.2.3
2.3.2.1

An AMORE program input.

A category of unit personnel which contains all the people with common skills, capabilities, and vulnerabilities. (Personnel within the same skill group are interchangeable.)

Probability of Degradation (PD)

Ref: Section 2.2.3
2.3.2.1

An AMORE program input.

This set of input contains the probabilities of degradation for each personnel skill group and equipment type and the commander's decision times for each.

Reconstitution Ref: Section 2.1.1.2	The simulated reorganization of the unit into essential teams. The reorganization is designed to achieve the maximum teams in the minimum time.
Repair Time	An AMORE program input.
Ref: Section 2.2.2.3 2.3.2.1	The average time to repair light and/or moderate materiel damage is entered into the AMORE model for every equipment type.
Severe Damage	A damage level for equipment.
Ref: Section 2.2.2.3	Severe damage cannot be repaired by the unit. Items with severe damage are lost to the unit.
Team	An increment of capability. The absolute minimum people and equipment who can perform the functions of a team is called an Essential Team.
Times at Which to Evaluate Capability.	An AMORE program input.
Ref: Section 2.2.4.1	Also called Time Slices. The times specified by the user at which capability is evaluated.
Time Slices	See Times at Which to Evaluate Capability.
Transfer Matrix	An AMORE program input.
See Section 2.2.2.4 2.3.2.1	A matrix containing the average transfer times for either personnel of a skill group to substitute into other skill groups or equipment of a type to substitute into other equipment types.
Transfer Time	The elements of a transfer matrix.
	These times are the average times required for the substitution to become operational at an acceptable level of competence.

Transportation Algorithm	A standard network algorithm used to solve the transportation problem. A rudimentary knowledge of the problem and the algorithm is assumed throughout this manual.
Zero Time Capability	See Initial Capability.

CHAPTER 2

THE AMORE COMPUTER MODEL

2.1 INTRODUCTION AND GENERAL INFORMATION

This chapter presents the user with a non-programmer's understanding of the AMORE computer model. The chapter is divided into three sections. The first section contains an overview of the software, followed by a brief discussion of the model's output options. The second section describes the model input data and methods used to develop this data. Lastly, a section concerning model output is included.

2.1.1 AMORE Model Overview

The AMORE model structure is shown in Figure 2-1. The figure shows that the simulation loop is performed for every Probability of Degradation (PD) Set entered. Multiple PD Sets can be used to simulate different levels of degradation on the same unit.

The iteration loop is nested within the simulation loop. Because of the stochastic processes used in the methodology, a single iteration of the entire procedure is insufficient to insure statistically acceptable results. Typically, twenty-five or more iterations are necessary. Each iteration consists of applying damage to the unit and assessing the number of survivors, optimally reallocating the surviving resources to build the maximum number of teams, and finally calculating unit capability at various times following the damage.

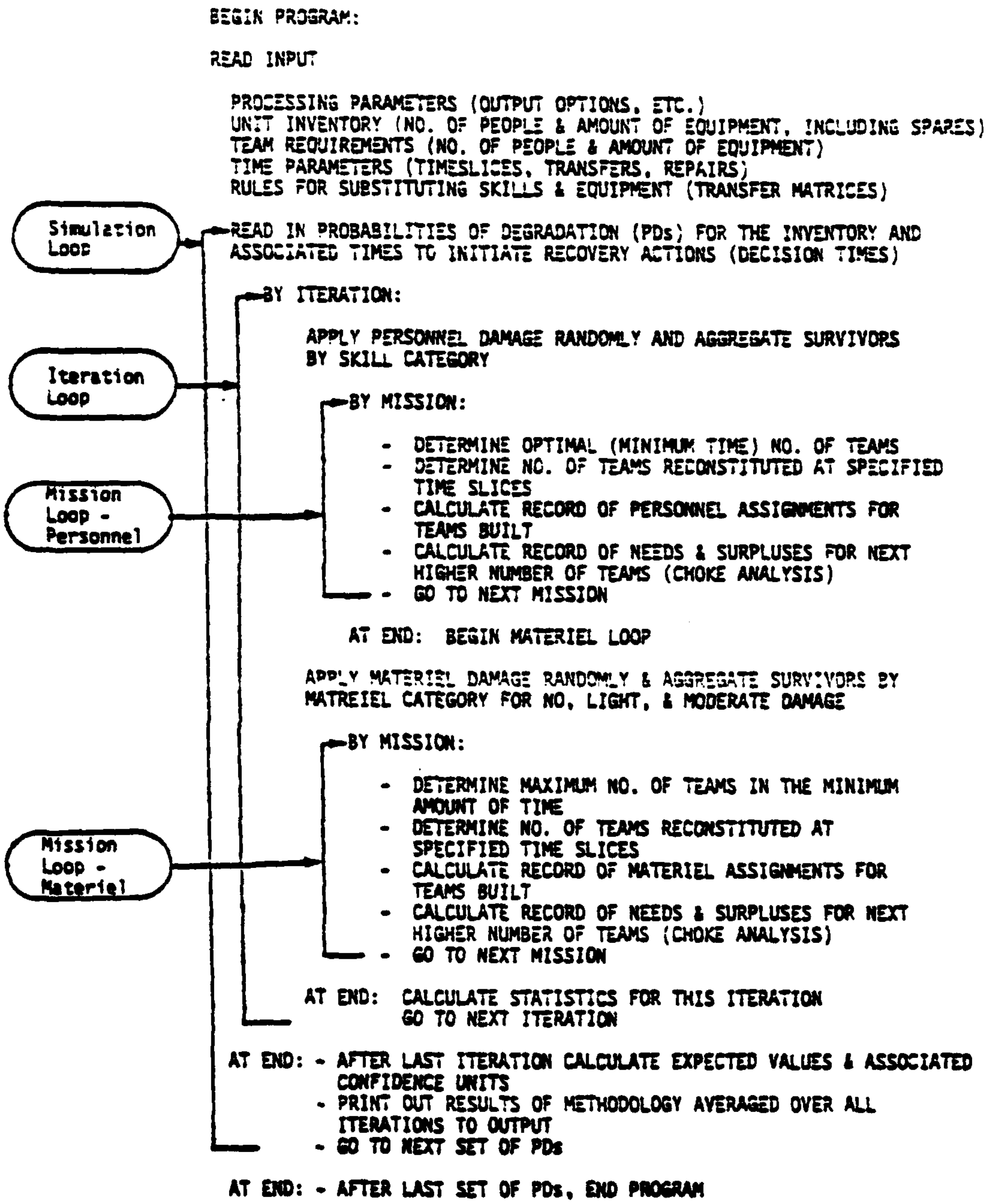


Figure 2-1. Iterative Structure of Program AMORE Processing Flow

These processes, within the iteration loop, are repeated for each mission defined by the user. This provides a means for examining and comparing, in a single execution of the model, a unit's capability to accomplish different missions following any particular degradation of its assets. These processes are performed first for personnel and then for the materiel items of the unit.

The iteration loop is repeated until a preselected number has been reached. (Use the Number of Iterations Option to select this number.) When all iterations have been completed, the capability results for each mission considered is printed. The model will repeat the simulation loop until all PD Sets have been considered.

Each iteration can be divided into three parts: the degradation, the reconstitution, and the capability calculations. A discussion of these parts follows.

2.1.1.1 The Degradation

The AMORE model simulates personnel degradation by dividing the unit into two groups: survivors and casualties. This terminology is used because organizations are often degradated by simulated attacks. This division is done by using the probabilities of degradation (PD) which were input for each personnel skill group. A uniformly distributed random number between 0 and 1.0 is generated for each individual and compared to the PD for that person's skill group. If this random number is greater than the PD, the person survives; if not, the person is declared a casualty and is considered unavailable to the unit.

Equipment degradation is conducted analogously, except that materiel items are divided into four categories: survivors, lightly damaged, moderately damaged, and severely damaged. Each equipment type has three PDs corresponding to the three levels of damage: light, moderate, and severe. The random number generated, when compared to the three PDs, determines which category of damage is assessed against an item. Items assessed as having light or moderate damage are made available after a delay which depends upon the unit's capability to perform necessary repairs. Items suffering severe damage are lost by the unit.

2.1.1.2 The Reconstitution

After degradation, the model establishes the maximum number of teams that can be rebuilt by the surviving personnel and materiel for each mission. It accomplishes this by using a binary search technique coupled with a transportation algorithm. The degradation defines the supply (the survivors) and the binary search is used to define the demand (the numbers of teams). The transportation algorithm determines if it is possible to reorganize the unit into the number of teams picked by the binary search, and if so, minimizes the times to reconstitute the unit (subject to supply and demand constraints). The search stops when it is possible to reorganize the degraded unit into a number of teams, but no more than that number. This number is the maximum number of teams which can be rebuilt by the unit.

2.1.1.3 The Capability Calculations

At the end of each iteration of the AMORE run, data is accumulated for statistics. These data will be used to calculate capability. Capability at a given time is the number of teams that the unit can build at that time, divided by the total number of teams. Capability is calculated at user selected times and at three additional times. Capability at these three extra times are called:

- Initial capability
- Minimum capability
- Maximum capability

Initial capability (sometimes called zero time capability) is the percent of total teams still intact immediately after degradation. This is unit capability before any reconstitution has occurred. Minimum capability is the percent of total teams obtained when the reconstitution begins. All transfers have started, but only those with zero transfer times have been completed. The maximum capability (sometimes called infinite time capability) is the capability obtained when all substitutions have been made. The maximum capability will show any late gain in capability.

All of these capabilities are calculated separately for materiel and personnel. The unit capability is the minimum of these two capabilities. These calculations are repeated for each mission under consideration. After all iterations are complete, these capability calculations will be printed as part of the standard model output. (See Section 2.3.2.) Optional AMORE features are discussed in the following section.

2.1.2 Available Options

2.1.2.1 Number of Iterations

The number of iterations for an AMORE run may be specified by the user. The minimum number required is two (2) and is necessary because of the statistical calculations use of "N-1" weighting. A two iteration run is normally used to evaluate the unit (and the input) with no damage. The number of iterations used to evaluate other damage cases is a function of the desired convergence of results. Fifty iterations have been found to provide generally acceptable convergence. Very high damage levels may require more iterations for acceptable convergence of results.

2.1.2.2 Choke Analysis

A choke analysis determines what assets are necessary to complete the next higher team. This is done by adding enough dummy supply assets to allow completion of that team. These dummy assets are given a very large transfer time and the transportation algorithm is again applied. The assignments of dummy assets identify the things (personnel or materiel) which are critical to the completion of that team because the large transfer times keep the assets from being used unless absolutely necessary.

The choke analysis reveals surplus skills and equipment items as well as those which are critical. Note that by analyzing different missions, choke analyses can be used to examine the strengths and/or weaknesses of an organization's TOE. This option can be selected with the Choke Analysis Flag. (See Section 2.2.4.3)

2.1.2.3 Multiple Optimal Solutions (MOS)

NOTE: This option can only be used when a choke analysis has been performed.

The analysis of the choke data may be expanded by examining multiple optimal solutions. Although the first solution found is an optimal solution in terms of minimizing time cost, there may be other solutions, still optimal, which require cheaper assets in terms of dollar costs, training costs, or general availability. This option allows the search for a specified number of alternate solutions or for all possible optimal solutions. Alternate solutions are sought only for those items which are critical to the building of the choke team. All alternate solutions for an iteration are averaged and the average solution for each iteration is stored. All iterations which choke on this team are then averaged for output. The limits of the distribution are also output, i.e. the minimum and maximum value for each choke point over all solutions found. The MOS option can be selected with the MOS flag (Section 2.2.4.4).

2.1.2.4 Assignment Matrices

When the assignment matrix option is used, the model records how the personnel and materiel resources are allocated when building the maximum number of teams. Since the model may not be able to build the same number of teams in every iteration, these assignments are accumulated separately for iterations with a common maximum number of teams. The elements of the matrices are the average assignments. The number of iterations and maximum number of teams which correspond to the assignments are noted on the matrix. This option can be selected with the assignment matrix flag (Section 2.2.4.5).

2.1.2.5 Mean Time Only

Typically, the transfer times for materiel and personnel and the repair times for materiel are treated as the means of exponentially distributed random variables. The times actually used during the simulation are sampled from the distributions defined by the mean times. The exponential distribution is used here since it is a frequently observed waiting time distribution. If this sampling procedure is not desired, the mean time only option can be used to by-pass it. This option can be selected with the mean time only flag (Section 2.2.4.6).

2.1.2.6 Input Only

A printout of the input data can be obtained by using the input only option. It is strongly recommended that the user verify the input data before running the complete simulation. This option can be selected with the input only flag (Section 2.2.4.7).

2.2 AMORE MODEL INPUT

2.2.1 Introduction

This section discusses both the AMORE model input and the analysis which is needed to develop the model input. Input to the model is listed in Figure 2-2. This list is not complete; variables such as those which set the dimensions of arrays in the model are not included. The discussion here is directed at the organizational analyst rather than the computer scientist. For technical information (card formats, FORTRAN variable names, etc.), refer to Chapter 3.

Throughout this section, the following sample problem will be used to illustrate the discussion.

The U.S. Army is modifying the table of organization and equipment (TOE) for a mechanized infantry company so that the unit will carry out its missions more effectively. A unit proposed TOE is to be examined.

Using the AMORE methodology, examine the mechanized infantry company in the mounted "attack" role. The mission is defined as a basic combat requirement which also requires maintenance and command and control (C^2). The unit's ability to reconstitute itself following enemy inflicted attrition is to be assessed during the six hour period after attack. Key personnel and materiel items which impact on the unit's capability are to be identified.

INPUT	REFERENCE SECTION
INPUT DETERMINED BY FUNCTIONAL ANALYSIS	2.2.2
1. Unit Missions	2.2.2.2
2. Initial Strengths	2.2.2.3
1. Personnel	
1. Name of each Personnel Skill Group	
2. Number of Personnel within each Skill Group	
2. Materiel	
1. Name of each Equipment Type	
2. Number of items in each Equipment Type	
3. Time (in minutes) to repair light damage	
4. Time (in minutes) to repair moderate damage	
3. Transfer Matrices	2.2.2.4
1. Personnel Transfer Matrix	
2. Materiel Transfer Matrix	
4. Requirements for Essential Teams	2.2.2.5
1. Requirements for Personnel Teams	
2. Requirements for Materiel Teams	
PROBABILTIY OF DEGRADATION (PD) SET INPUT	2.2.3
1. Title of PD Set	
2. Personnel	
1. Probabilities of Degradation	
2. Commander's Decision Time (in minutes)	
3. Materiel	
1. Probability of Light Damage	
2. Probability of Moderate Damage	
3. Probability of Severe Damage	
4. Commander's Decision Time (in minutes)	
OTHER INPUT	2.2.4
1. Times at which to evaluate capability	2.2.4.1
2. Number of Iterations	2.2.4.2
3. Choke Analysis Flag	2.2.4.3
4. Multiple Optimal Solution (MOS) Flag	2.2.4.4
5. Assignment Matrices Flag	2.2.4.5
6. Mean Time Only Flag	2.2.4.6
7. Input Only Flag	2.2.4.7

Figure 2-2. AMORE Model Input

2.2.2 Input Related to Functional Analysis

2.2.2.1 Introduction

The functions of the organization and how the functions interrelate must be determined. These functions are actions which must be performed to accomplish the mission. As an example, the attack mission demands the functions: target detection, target identification, target assignment, target engagement, target surveillance and, if necessary, reengagement. There are sub-functions such as movement in order to engage or, in some cases, survival to reengage.

These functions are related to the unit by using a functional analysis. Once the functions required by the mission are identified, the functional analysis is used to address more pointed questions. These questions include the following:

Who performs which function?
What equipment is needed for each function?
In what order are functions performed?
How long does each take?
How many people and how much materiel is needed?

2.2.2.2 Unit missions

The unit mission is not input in the literal sense, but it is of primary importance to the analysis because the mission determines the requirements for essential teams. (See Section 2.2.2.5). A mission which requires most of the skills groups and equipment types will generally provide the most information, because it forces the unit to draw upon its resources. Unit missions should also make simultaneous demands on multiple functions within the organization. Do not forget the day-to-day routine demands on a unit which occur at the same time as the high priority demands of a particular mission.

Analyses of more than one mission (team construct) may be required in order to understand an organization's ability to function under pressure.

2.2.2.3 Initial strengths

The initial strengths are the predegradation inventories of the individuals within the personnel skill groups and the items within the equipment types. These initial strengths specify the total supply available in each category. The usual source of information for this input is the unit TOE. Note that by changing the initial strengths, changes in the unit TOE can be assessed by the AMORE methodology.

The user may name each personnel skill group and equipment type as well as specifying the number of people or things within the categories. The personnel skill groups and equipment types are numbered in the order in which they are entered into the computer. These numbers are the personnel and equipment line numbers, which serve to index these categories. Output from the model is labelled with the entered names and numbered with the line numbers.

Further input is required for materiel. Recall that equipment damage is sorted into damage that can be repaired by the crew (light damage), damage that requires higher level repair but can be repaired within the unit (moderate damage), damage that must be evacuated for repair or is unrepairable, and finally undamaged equipment (no repair required). The repair times for light and moderate damage are included in order to realistically model materiel reconstitution. These times are usually a result of research, surveys, and an examination of maintenance records.

EXAMPLE: Initial Strength

In the mechanized infantry company example, capability of the unit with a proposed TOE is to be assessed. Therefore, the initial strengths are defined directly from the TOE and listed in Figures 2-3 and 2-4. Note that the line numbers are included in the figures.

The damage repair times for materiel are listed in Figure 2-5. Assume (for example purposes) that they represent the average repair times for each equipment type, according to maintenance records.

2.2.2.4 Transfer Matrix

For a unit commander in combat the balancing of resources against mission requirements is essentially a supply and demand problem. Commanders are always reconstituting their units, even in peacetime. They consider the assets on hand and the demands of the mission(s) at hand. The exercise of command becomes a continuous reallocation of resources to meet the mission and functional demands. In AMORE, the representations of allocation potential are the transfer matrices.

A transfer matrix indicates how long each personnel or materiel substitution takes to complete. Each transfer matrix has row and column headings which correspond to the personnel or materiel line numbers. Personnel or equipment defined by the rows will substitute for those defined by the columns. Matrix entries represent the average time (minutes) for the substitution to be operational with an acceptable degree of capability. Zeros occur when the substitution is operational immediately. The diagonal elements (same row and column number) are all zero since the diagonal elements represent the time it takes for a personnel skill or equipment type to fill in for

LINE	PERSONNEL SKILL GROUPS	INITIAL STRENGTHS
1	CO	1
2	XO	1
3	1 SGT	1
4	SUPPLY SGT	1
5	TAC COMM CHIEF	1
6	ARMORER	1
7	CARRIER DRIVER	20
8	RTO	6
9	SUPPLY MAN	1
10	MOTOR SGT	1
11	SR RECOVERY VEH OP	1
12	SR TRACK VEH MECH	1
13	EQUIPMENT MAINT CLK	1
14	TAC COMM SYS OP/MECH	1
15	RECOVERY VEH OP	1
16	TRACK VEH MECH	5
17	RIFLE PLT LDR	3
18	RIFLE PLT SGT	3
19	ASST PLT SGT	3
20	SQUAD LDR	9
21	TEAM LDR	18
22	AUTO RIFLEMAN	18
23	GRENADIER	18
24	RIFLEMAN	27
25	WPN PLT LDR	1
26	WPN PLT SGT	1
27	MORTAR SEC LDR	1
28	FIRE DIR CMPT	2
29	MORTAR SQD LDR	3
30	MORT GUNNER/ASST GUNNER	6
31	AMMO BEARER	3
32	ANTITANK SEC LDR	1
33	ANTITANK SQD LDR	1
34	TOW GUNNER	2
35	ASST TOW GUNNER	2
		TOTAL 166

FIGURE 2-3. Personnel Initial Strengths Mech Infantry Company

LINE	EQUIPMENT TYPE	INITIAL STRENGTH
1	CO CARRIER (KY38, GRA-39, VRC-46, VRC-47, PRC-77)	1
2	XO CARRIER (KY38, GRA-39, VRC-46, PRC-77)	1
3	TRUCK 1/4T (KY38, GRA-39, VRC-46, PRC-77)	1
4	TRAILER 1/4T	1
5	TRUCK 2 1/2T SUPPLY	1
6	TRAILER 1 1/2T SUPPLY	1
7	RECOVERY VEHICLE (VRC-46)	1
8	TRUCK 2 1/2T MAINT	2
9	TRAILER 1 1/2T MAINT	1
10	PLT LDR CARRIER (PRR-9, GRC-160)	3
11	RFL SQD LDR CARRIER (PRR-9, GRC-160)	9
12	TRUCK 1/4T PLT HQs (GRC-160, VRC-46)	2
13	TRAILER 1/4T PLT HQs	2
14	MORTAR SEC HQs CARRIER (GRC-160)	1
15	MORTAR CARRIER (GRC-160)	3
16	TOW CARRIER (CRC-160)	2
17	MG 7.62	15
18	DRAGON ANTITANK WPN	9
19	RIFLE 5.56	153

Parenthesis indicate radios associated with vehicles

FIGURE 2-4. Materiel Initial Strengths Mech Infantry Company

LINE	EQUIPMENT TYPE	DAMAGE REPAIR TIMES LIGHT	MODERATE
1	CO CARRIER	60	240
2	XO CARRIER	60	240
3	TRUCK 1/4T	45	180
4	TRAILER 1/4T	15	90
5	TRUCK 2 1/2T SUPPLY	45	180
6	TRAILER 1 1/2T SUPPLY	15	90
7	RECOVERY VEH	60	240
8	TRUCK 2 1/2T MAINT	45	180
9	TRAILER 1 1/2T MAINT	15	90
10	PLT LDR CARRIER	60	240
11	SQD LDR CARRIER	60	240
12	TRUCK 1/4T PLT HQ	45	180
13	TRAILER 1/4T PLT HQ	15	90
14	MORTAR SEC HQ CARRIER	60	240
15	MORTAR CARRIER	60	240
16	TOW CARRIER	60	240
17	MG 7.62	30	180
18	DRAGON ANTI TANK	30	180
19	RIFLE 5.56	15	60

FIGURE 2-5. Times (Minutes) to Repair Light and Moderately Damaged Equipment.

itself. A number other than zero in the matrix represents the time in minutes for that substitution to reach an acceptable level of capability in performance. When a particular transfer is not allowed (usually because the time involved is too long), a negative number is entered into the model. Infeasible transfers are indicated by a '.' instead of a number in the transfer matrix print-outs.

Developing a personnel transfer matrix requires one or two decisions per row/column cell. Can an individual with the row skill substitute for someone with the column skill? If so, how long does it take on the average for the substituted skill to attain acceptable operational capability? The elements of the transfer matrix are estimates of the time needed to move to a different location and/or become reasonably proficient at a different skill. The decisions made when developing this matrix are usually based upon common sense and experience.

The materiel transfer matrix is developed similarly to the personnel transfer matrix. Each entry in the matrix requires one or two decisions. Can the row item substitute for the column item? If so, is there a transfer time required to make the item ready for its new function within unit resources? For example, the executive officer's carrier can become the company command carrier (assuming colocation) at no cost in time. A TOW carrier can become the command carrier, but time is required to change radios to provide the proper netting capability for the substituted carrier. Decisions made about the materiel transfer matrix tend to be more straightforward than the analogous decisions for personnel.

EXAMPLE: Transfer Matrices

Figures 2-6 and 2-7 are the transfer matrices for the mechanized infantry company. The number heading the rows and columns of

TRANSFER MATRIX FOR PERSONNEL

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1	0	0	0	30	.	.	0	0	0	.	30	.	30	.	10	.	0	0	0	0	0	0	0	0	0	0	0	15	0	15	0	0	0	10	0
2	0	0	0	30	.	.	0	0	0	.	30	.	30	.	10	.	0	0	0	0	0	0	0	0	0	0	0	15	0	15	0	0	0	10	0
3	15	0	0	30	.	.	0	0	0	10	30	.	30	.	10	.	0	0	0	0	0	0	0	0	30	15	15	15	0	15	0	0	0	10	0
4	.	.	60	0	.	0	.	0	0	.	.	.	10	.	.	10	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	10	20	5
5	.	.	60	30	0	.	.	0	0	.	.	.	10	0	.	10	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	10	20	5
6	.	.	.	30	.	0	.	10	0	.	.	.	10	.	.	10	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	.	30	5
7	.	.	.	.	.	.	0	0	10	.	30	.	.	.	10	30	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	.	.	5
8	.	.	.	.	.	.	.	0	10	.	.	.	.	30	.	.	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	.	.	5
9	.	.	.	60	.	30	.	10	0	.	.	.	10	.	.	.	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	.	.	5
10	.	.	60	30	.	30	0	0	0	0	0	0	0	.	0	0	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	10	20	5
11	.	.	.	.	.	.	0	0	0	30	0	30	10	.	0	0	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	.	.	5
12	.	.	.	.	.	30	0	0	0	30	10	0	10	.	0	0	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	.	.	5
13	.	.	.	60	.	.	.	10	0	.	.	.	0	.	.	10	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	.	.	5
14	.	.	.	.	30	.	.	0	10	.	.	.	30	0	.	10	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	.	.	5
15	.	.	.	.	.	.	0	0	10	60	10	60	30	.	0	.	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	.	.	5
16	.	.	.	.	.	60	0	10	10	.	30	30	30	.	10	0	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	.	.	5
17	30	15	15	30	.	.	0	0	0	.	30	.	30	.	10	.	0	0	0	0	0	0	0	0	10	0	0	15	0	15	0	0	0	10	0
18	60	30	30	.	.	.	0	0	0	.	30	.	30	.	10	.	0	0	0	0	0	0	0	0	30	15	15	30	0	15	0	0	0	10	0
19	.	.	.	.	.	.	0	0	0	.	30	.	30	.	10	.	30	10	0	0	0	0	0	0	60	30	30	.	0	15	0	0	10	30	0
20	.	.	.	.	.	.	0	0	0	.	.	.	.	.	.	.	.	30	10	0	0	0	0	0	.	.	.	.	.	.	0	30	10	30	5
21	.	.	.	.	.	.	0	0	0	.	.	.	.	.	.	.	.	60	30	10	0	0	0	0	.	.	.	.	.	.	0	.	.	.	5
22	.	.	.	.	.	.	10	10	10	.	.	.	.	.	.	.	.	.	.	.	10	0	0	0	.	.	.	.	.	.	0	.	.	.	5
23	.	.	.	.	.	.	10	10	10	.	.	.	.	.	.	.	.	.	.	.	10	0	0	0	.	.	.	.	.	.	0	.	.	.	5
24	.	.	.	.	.	.	10	10	10	.	.	.	.	.	.	.	.	.	.	.	30	0	0	0	.	.	.	.	.	.	0	.	.	.	5
25	30	15	15	30	.	.	0	0	0	10	30	.	30	.	10	.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
26	60	30	30	.	.	.	0	0	0	.	30	.	30	.	10	.	15	10	0	0	0	15	15	0	0	0	0	0	0	0	0	0	0	10	0
27	.	.	.	.	.	.	0	0	0	.	30	.	30	.	10	.	.	30	10	30	10	15	15	0	30	10	0	0	0	0	0	10	0	10	5
28	.	.	.	.	.	.	.	0	0	.	.	.	.	.	.	.	.	.	.	.	.	15	15	0	.	30	0	0	10	10	0	.	.	.	5
29	.	.	.	.	.	.	0	0	0	.	.	.	.	.	.	.	.	.	.	.	30	15	15	0	.	.	10	10	0	0	0	15	10	15	5
30	.	.	.	.	.	.	10	10	10	.	.	.	.	.	.	.	.	.	.	.	.	15	15	0	.	.	30	30	10	0	0	30	.	.	5
31	.	.	.	.	.	.	10	10	10	.	.	.	.	.	.	.	.	.	.	.	.	15	15	0	.	.	.	.	.	10	0	.	.	.	5
32	.	.	.	.	.	.	0	0	0	.	30	.	30	.	10	.	.	30	10	30	10	15	15	0	30	10	10	10	10	10	0	0	0	0	0
33	.	.	.	.	.	.	0	0	0	.	.	.	.	.	.	.	.	.	.	.	30	15	15	0	.	30	30	30	30	15	0	10	0	0	0
34	.	.	.	.	.	.	10	10	10	.	.	.	.	.	.	.	.	.	.	.	.	15	15	0	.	.	.	.	.	30	0	10	0	0	0
35	.	.	.	.	.	.	10	10	10	.	.	.	.	.	.	.	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	10	0	0

Figure 2-6. Personnel Transfer Matrix

TRANSFER MATRIX FOR MATERIAL

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	0	0	0	.	30	.	.	30	.	0	0	0	.	0	30	.	.	.	.
2	0	0	0	.	30	.	.	30	.	0	0	0	.	0	30	.	.	.	.
3	.	.	0	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.	.
4	.	.	.	0	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.
5	.	.	30	.	0	.	.	10	.	.	.	30	.	.	.	.	.	.	.
6	.	.	.	.	.	0	.	.	0	.	.	.	.	.	.	.	.	.	.
7	.	.	10	.	.	.	0	.	.	.	.	10	.	.	.	.	.	.	.
8	.	.	30	.	10	.	.	0	.	.	.	30	.	.	.	.	.	.	.
9	.	.	.	.	.	0	.	.	0	.	.	.	.	.	.	.	.	.	.
10	10	10	0	.	30	.	.	30	.	0	0	0	.	0	30	.	.	.	.
11	10	10	0	.	30	.	.	30	.	0	0	0	.	0	30	.	.	.	.
12	.	.	10	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.	.
13	.	.	.	0	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.
14	30	30	0	.	30	.	.	30	.	10	0	0	.	0	30	.	.	.	.
15	30	30	0	.	30	.	.	30	.	30	30	0	.	0	0	.	.	.	.
16	30	30	0	.	.	.	.	.	.	.	.	0	.	0	.	0	.	.	.
17	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	.	.
18	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	.
19	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0

Figure 2-7. Materiel Transfer Matrix.

the matrices (1 through 35 for personnel, 1-19 for materiel) relate to the personnel and materiel line numbers which were assigned when the initial strengths were set up. (See Section 2.2.2.3) Each cell of both matrices represents judgements about substitutability made by the analyst. The analyst draws upon all knowledge of the organization, personnel skill groups, and equipment types in order to make these decisions.

2.2.2.5 Requirements for essential teams

It is here that the user must specify how the mission is to be performed. The user must answer such questions as: what are the increments of capability? Should the first increment (team) include the company commander or a platoon leader? Where should maintenance be included?

A helpful question, at this point: if only one increment of capability could be built, what should it contain? Next, if only two increments of capability could be built, what should they contain? The second increment of capability will be the difference between the above two answers. This process is continued until all required functions are accounted for.

This step requires merging personnel and materiel to form essential teams. The user should remember that resources are limited. The addition of materiel may generate the need for more skills (to maintain, to hook-up, etc.). Therefore, the personnel skills and materiel items assigned to a team must be essential to the team. In other words, it must be true that the team could not perform its function without all of its assigned personnel skills and materiel items. Caution should be taken not to assign personnel skills and materiel items without which the function can still be performed. Where the issue is in doubt, the AMORE methodology can be used to ascertain the difference in unit capability obtained by adding the desired skill or item. It can then be determined if the addition is justified. A personnel skill or equipment item should not be required by a team unless it is needed to perform the teams function.

Teams do not have to be either linear or homogeneous. For most analyses, however, it is prudent to develop equal slices of capability and have each team represent that equal slice. In any case, the final building of the teams is reserved for the last step to accommodate the insights previously developed during the building of the transfer matrices. It may take a few attempts to determine the requirements for essential teams.

EXAMPLE: Requirements for Essential Teams

By conducting a thorough analysis of the unit TOE and the mission it is expected to accomplish, three basic functions (attack, C^2 and maintenance) are to be performed by the unit. The first is the attacking of the enemy position by the infantry teams mounted in carriers. Included in this are mounted supporting weapon systems. The second is the command and control of these teams by company and platoon headquarters. The last is providing maintenance support to all elements involved in the attack. The latter two functions are also to be performed using vehicles with the same mobility characteristics as those used by the infantry teams.

Any one of a number of ways may be used to determine the skill requirements for the essential teams needed to perform the three basic functions. For the sake of clarity, the method of pyramiding command control requirements is used. Assume this begins with eighteen minimum infantry fire teams establishing the basis for each team within the company. Each fire team has a team leader, an automatic rifleman, a grenadier and a rifleman. This initial assignment is as shown in Figure 2-8.

LINE	SKILL	REQUIREMENTS FOR ESSENTIAL TEAMS 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	TOT	UN-USED
21	TEAM LDR	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	0
22	AUTO RIFLE-MAN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	0
23	GRENADIER	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	0
24	RIFLEMAN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	9

Figure 2-8. Example of Essential Team Build

For direct command and control of these teams, a squad leader is assigned to supervise each pair. Projecting these control personnel onto the previous array, the results are as depicted in Figure 2-9. For this problem solution, it is determined that three fire teams require the supervision of a platoon leader (the next higher echelon of command contol). So, the platoon leaders are assigned to the third fire team within their respective platoons. Since each complete platoon consists of three complete squads, this assignment results in the information matrix in Figure 2-10.

The company commander, the final command and control, is assigned at the point where the first platoon is complete and the second platoon has only one fire team. By adding the company commander to this team position (Team 7), the requirement matrix becomes that which is shown in Figure 2-11.

LINE	SKILL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	TOT	UN-USED
		REQUIREMENTS FOR ESSENTIAL TEAMS																			
20	SQUAD LDR		1		1		1		1		1		1		1		1		1	9	0
21	TEAM LDR	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	0
22	AUTO RIFLE-MAN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	0
23	GRENADIER	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	0
24	RIFLEMAN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	9

Figure 2-9. Example of Essential Team Build.

LINE	SKILL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	TOT	UN-USED
		REQUIREMENTS FOR ESSENTIAL TEAMS																			
17	RIFLE PLT LDR			1						1						1				3	0
20	SQUAD LDR		1		1		1		1		1		1		1		1		1	9	0
21	TEAM LDR	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	0
22	AUTO RIFLE-MAN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	0
23	GRENADIER	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	0
24	RIFLEMAN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	9

Figure 2-10. Example of Essential Team Build.

LINE	SKILL	REQUIREMENTS FOR ESSENTIAL TEAMS 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	TOT	UN-USED
1	COMPANY COMMANDER							1												1	0
17	RIFLE PLT LDR			1						1						1				3	0
20	SQUAD LDR		1		1		1		1		1		1		1		1		1	9	0
21	TEAM LDR	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	0
22	AUTO RIFLE-MAN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	0
23	GRENADIER	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	0
24	RIFLEMAN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	9

Figure 2-11. Example of Essential Team Build

At this point the basic infantry teams along with appropriate levels of command and control have been established. To complete the matrix only the assignments of maintenance personnel, drivers, mortar squads and anti-tank crews remain. Note that nine riflemen are not required by essential teams. They will be candidates for replacements during reconstitution. Before continuing with personnel assignments, however, a description of the building of corresponding essential materiel teams is in order.

A carrier and DRAGON are assigned to each team containing a squad leader. Additionally a carrier is assigned to each team containing a platoon leader and the one containing the company commander. Finally, each carrier assigned thus far is assigned a machine gun. This then makes the initial essential equipment teams appear as depicted in Figure 2-12.

LINE	ITEM	REQUIREMENTS FOR ESSENTIAL TEAMS 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	TOT	UN-USED
1	CO CARRIER							1												1	0
10	PLT LDR CARRIER			1						1						1				3	0
11	SQD LDR CARRIER		1		1		1		1		1		1		1		1		1	9	0
17	MG 7.62		1	1	1		1	1	1	1	1		1		1	1	1		1	13	2
18	DRAGON		1		1		1		1		1		1		1		1		1	9	0

Figure 2-12. Example of Essential Team Build.

From here on, logic, common sense and experience play important roles in the assignment of the remaining portion of the company's resources allotted to the attack mission. From a mobility standpoint there is a distinct advantage in assigning a carrier to each team. However, an examination of the initial materiel teams reveals that teams 1, 5, 11, 13 and 17 remain without transport. For this solution, the position is taken that this is to be afforded by assignment of the supporting weapons' carriers (TOWs and mortars).

The lowest level at which the TOW would be expected to be deployed and controlled is assumed to be at the squad level. This is accomplished by moving the squad leader carrier in team 2 to team 1 and assigning the first TOW carrier to team 2. The second TOW carrier is assigned to team 11 to lend balance with the mortar carriers assigned to the remaining teams lacking transport (teams 5, 13 and 17). Returning to the personnel teams, the crews associated with these supporting weapons are now assigned. Additionally a carrier driver is assigned to each of the eighteen teams as each now contains a carrier. Next, the maintenance personnel are assigned to team 7 for the purpose of being under centralized control of the company commander.

The recovery vehicle being associated with maintenance personnel is now added to team 7 of the materiel teams. Finally the rifles are assigned to personnel in each team that are authorized to carry that weapon. For example, all personnel except the company commander and the recovery vehicle operator carry rifles. Their weapons are considered insignificant in this problem solution and are not entered into the materiel teams.

The assignment of essential personnel and equipment into teams is now complete as depicted by the requirements shown in Figure 2-13 and 2-14.

The method just used to build the essential personnel and materiel teams is only one of many. It may be noted that some assignments of resources were linear (infantry fire teams) while others were made for reasons which satisfied a particular logic. There is no reason why this or any other organization could not have teams built to suit the purposes of the user. Different analysts may develop different essential teams, yet each team build could be analytically valid.

2.2.3 Probability of Degradation (PD) Set Input

Each probability of degradation (PD) set contains the degradation probabilities for personnel and materiel, as well as the commander's decision times (in minutes) for personnel and materiel reconstitution. The user may also input a name for the PD set, if desired for output titling.

Unit posture and the threat being simulated determine the probability of degradation inputs to the model. The availability of PD sets for both personnel and materiel enable the user to tailor the simulated degradation to the military unit and the analysis. Degradation is assessed stochastically by the AMORE model; the greater

LINE	SKILL	REQUIREMENTS FOR ESSENTIAL TEAMS																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	TOT	UN-USED
1	COMPANY COMMANDER							1												1	0
7	CARRIER DRIVER	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	2
10	MOTOR SGT							1												1	0
15	RECOVERY VEH OP							1												1	0
16	TRACK VEH MECH							2												2	3
17	RIFLE PLT LDR			1						1						1				3	0
20	SQUAD LDR		1		1		1		1		1		1		1		1		1	9	0
21	TEAM LDR	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	0
22	AUTO RIFLE-MAN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	0
23	GRENADIER	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	0
24	RIFLEMAN	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18	9
29	MORTAR SQD LDR					1								1				1		3	0
30	MORTAR GUNNER					2								2				2		6	0
32	ANTI TANK SEC LDR		1																	1	0
33	ANTI TANK SQD LDR											1								1	0
34	TOW GUNNER		1									1								2	0

Figure 2-13. Requirements for Essential Personnel Teams

LINE	ITEM	REQUIREMENTS FOR ESSENTIAL TEAMS																		TOT	UN-USED
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
1	CO CARRIER							1												1	0
7	RECOVERY VEH							1												1	0
10	PLT LDR CARRIER			1						1						1				3	0
11	SQD LDR CARRIER	1			1		1		1		1		1		1		1		1	9	0
15	MORTAR CARRIER					1								1				1		3	0
16	TOW CARRIER		1									1								2	0
17	MG 7.62		1	1	1		1	1	1	1	1		1		1	1	1		1	13	2
18	DRAGON		1		1		1		1		1		1		1		1		1	9	0
19	RIFLE 5.56	5	8	6	6	8	6	8	6	6	6	7	6	8	6	6	6	8	6	118	35

Figure 2-14. Requirements for Essential Materiel Teams.

the PD, the more likely that the personnel skill group or materiel type will be degraded. Degradation probabilities are input to the model based on an analysis of the particular degrading mechanism (i.e., nuclear, conventional, or chemical weapons, drug abuse, assignment policy, etc.) and the vulnerability of the unit assets.

When the degrading mechanism is an enemy weapon, the PD's can usually be derived using Joint Munitions Effectiveness Manual (JMEM) methodologies. These methodologies are universally accepted and can be used to develop PD sets which reflect the posture of the organization and the attacking munition.

Materiel probabilities of degradation, which are developed concurrently with the personnel PDs, are input in a different format since three analytically determined PDs (user inputs) for a given materiel category for light damage, moderate damage, and severe damage are required. These values must be input cumulatively, in descending order, to satisfy the degradation algorithm. To determine these, consider the set of PD values shown in Figure 2-15. In the left frame, four sets of values are shown noncumulatively, as determined analytically with respect to the particular AMORE application. The right frame shows them in the cumulative form as required for data entry to run the AMORE program. The column labeled 'AT LEAST LIGHT' contains the sum of the light, moderate, and severe damage probabilities and the column labeled 'AT LEAST MODERATE' contains the sum of the PDs for moderate and severe damage.

Examples of Noncumulative PDs				The Cumulative PDs for Input		
NO DAMAGE	LIGHT	MODERATE	SEVERE	AT LEAST LIGHT	AT LEAST MODERATE	SEVERE
.86	.05	.06	.03	.14	.09	.03
.89	.05	.06	.00	.11	.06	.00
.95	.05	.00	.00	.05	.00	.00

Figure 2-15. Example of Materiel PD Set

The commander's decision times are used to simulate the time needed for the commander to assess the condition of the unit and decide how to reorganize. The decision times are added to all of the non-diagonal numeric elements of the personnel and materiel transfer matrices. (Recall that the numeric elements denote possible substitutions; decision times are not added to diagonal elements because people and equipment within the same personnel skill group or equipment type are assumed to perform their own job without command to do so.)

NOTE: The minimum capability (See Section 2.1.1.3) measures the capability of the unit at a time when other transfers are in progress and only these automatic job fills are operational.

EXAMPLE: PD Sets

Figure 2-16 contains the personnel PDs and Figure 2-17 contains the cumulative materiel PDs for the mechanized infantry company example. Assume that these probabilities were derived using JMEM methodologies. These methodologies require some knowledge of the attacking munition and organization posture. For instance, by assuming that the mechanized infantry company in a mounted attack role was being attacked by an enemy aircraft loaded with a known type of guided missiles, the analyst could use JMEM methodologies to determine degradation probabilities.

LINE	SKILL	DEGRADATION PROBABILITY
1	COMPANY COMMANDER	.15
2	EXECUTIVE OFFICER	.13
3	FIRST SERGEANT	.13
4	SUPPLY SERGEANT	.13
5	TAC COMM CHIEF	.13
6	ARMORER	.13
7	CARRIER DRIVER	.18
8	RTO	.13
9	SUPPLYMAN	.13
10	MOTOR SERGEANT	.15
11	SR RECOVERY VEH OP	.13
12	SR TRACK VEH MECH	.13
13	EQUIP MAINT CLERK	.13
14	TAC COMM SYS OP/MECH	.13
15	RECOVERY VEH OP	.15
16	TRACK VEH MECH	.15
17	RIFLE PLT LDR	.18
18	RIFLE PLT SGT	.13
19	ASST PLT SGT	.13
20	SQUAD LDR	.18
21	TEAM LDR	.18
22	AUTO RIFLEMAN	.18
23	GRENADIER	.18
24	RIFLEMAN	.18
25	WPN PLT LDR	.13
26	WPN PLT SGT	.13
27	MORTAR SEC LDR	.14
28	FIRE DIR CMPT	.13
29	MORTAR SQD LDR	.14
30	MORTAR GUNNER	.14
31	AMMO BEARER	.13
32	ANTI TANK SEC LDR	.18
33	ANTI TANK SQD LDR	.18
34	TOW GUNNER	.18
35	ASST TOW GUNNER	.18

- COMMANDER DECISION DELAY TIME 5 MINUTES

Figure 2-16. Probability of Personnel Degradation

LINE	ITEM	CUMULATIVE DAMAGE PROBABILITIES		
		AT LEAST LIGHT (TOTAL)	AT LEAST MODERATE (MOD & SEV)	SEVERE
1	CO CARRIER	.300	.220	.080
2	XO CARRIER	.270	.190	.060
3	TRUCK ¼ T	.270	.190	.060
4	TRAILER ¼ T	.270	.190	.060
5	TRUCK 2½ T SUPPLY	.270	.190	.060
6	TRAILER 1½ T SUPPLY	.270	.190	.060
7	RECOVERY VEH	.300	.220	.080
8	TRUCK 2½ T MAINT	.270	.190	.060
9	TRAILER 1½ T MAINT	.270	.190	.060
10	PLT LDR CARRIER	.350	.250	.120
11	SQD CDR CARRIER	.350	.250	.120
12	TRUCK ¼ T PLT HQ	.270	.190	.060
13	TRAILER ½ T PLT HQ	.270	.190	.060
14	MORTAR SEC HQ CARRIER	.270	.190	.060
15	MORTAR CARRIER	.280	.200	.080
16	TOW CARRIER	.350	.250	.120
17	MG 7.62	.350	.250	.120
18	DRAGON ANTI TANK	.350	.250	.120
19	RIFLE 5.56	.350	.250	.120

- COMMANDERS DECISION DELAY TIME 10 MINUTES

Figure 2-17. Cumulative Probabilities of Materiel Degradation

In this example the commander's decision times for reconstitution of materiel and personnel are assumed to be 10 minutes and five minutes respectively. These decision times could have been derived from interviews with wartime company commanders.

2.2.4 Other Input

2.2.4.1 Times at which to evaluate capability

The user is able to specify times (in hours) at which to evaluate capability. Times of interest are determined by the analysis to be performed.

EXAMPLE: Times at which to evaluate capability

Capability will be determined every quarter hour up until six hours after attack.

2.2.4.2 Number of iterations

An integer greater than or equal to two must be entered as the number of iterations. Experience has shown that fifty iterations are generally sufficient to provide statistically significant convergence of results.

EXAMPLE: Number of iterations

Fifty iterations were used in the analysis of the mechanized infantry company.

2.2.4.3 Choke analysis flag

When this flag equals one, the choke analysis is performed and the results are printed. When the flag equals zero, the choke analysis is bypassed. (See paragraph 2.1.2.2)

2.2.4.4 Multiple optimal solution (MOS) flag

This option enables the user to specify the desired number of multiple optimal "choke" solutions to be derived for personnel and materiel by entering that number. An important exception is that the user must enter the value zero to obtain only one optimal solution. A value of one causes a search for all possible solutions. Normally, the user does not enter the value one due to the large amount of computer time consumed by a search for all possible solutions.

NOTE: The choke analysis flag must equal one in order to use this option. (See paragraph 2.1.2.3)

2.2.4.5 Assignment matrices flag

If this output option is chosen, then the assignment matrix, which contains the average assignment made in the unit reconstitution process, is printed. This variable is valued either zero or one. A value of one causes the calculation and output of personnel and materiel assignment matrices for all iterations with a common maximum number of teams. (See paragraph 2.1.2.4)

2.2.4.6 Mean time only flag

When this flag equals zero, the time required for personnel or materiel transfer, as well as repair times for materiel, are sampled from exponential distributions with means determined by the input data. When this flag equals one, the elements of the transfer matrices and the repair times are used as entered without the sampling process. (See paragraph 2.1.2.5)

2.2.4.7 Input only flag

When this flag equals one, the model will process and list input data without main program processing. When this flag equals zero, main program processing occurs and input data as well as selected output are printed.

2.2.5 Verification of Input

Good data processing techniques require that input data be verified as being correct prior to program execution. This is done in order to avoid costly computer reruns resulting from erroneous input. If the input only flag equals one, only the input data is printed in the order and format in which it was read. No further processing takes place, thereby permitting the user to check data for corrections.

Usually, an AMORE run is made for a unit using a zero PD set. This tests whether the input organization can do what it is designed to do by determining how many personnel and materiel teams can be built with no degradation of assets. If the required number of teams cannot be built, either the input data is erroneous or the unit was designed incorrectly. Note that when no degradation is assessed all solutions will be the same. Therefore a minimum number of iterations are required for the assessment. The minimum allowed by the model is two (2) because of the "N-1" weighting in statistical calculations.

On the other hand, an organization with zero PDs may be able to build more teams than was originally perceived. In this case, the user may wish to modify the initial strengths or the requirements for essential teams.

2.3 AMORE MODEL OUTPUT

2.3.1 Introduction

This portion of the user's manual is designed to provide the user with an understanding of the various forms of output produced by program AMORE. With this knowledge, the user will be able to more effectively perform solution analyses. However, detailed discussion on output analysis techniques will not be conducted as it is beyond the intended scope of this manual.

All sample output in this section applies to the mechanized infantry company example problems. AMORE Model Output is listed in Figure 2-18.

2.3.2 Standard Output

2.3.2.1 Input Data

Input data for each AMORE run is always printed for verification by the user. If the Input Only Flag is on, then the simulation is not made and only the input data is printed. Otherwise, both the input data and the analysis results are printed. The output format of the input data is the same in either case. Sample printouts are provided in Figure 2-19.

AMORE MODEL OUTPUT	REFERENCE SECTION
STANDARD OUTPUT.	2.3.2
1. Input Data	2.3.2.1
1. Flags and Times for Capability Calculations	
2. Personnel Data: Initial Strength	
3. Materiel Data: Initial Strength, Light and Moderate Damage Repair Times	
4. Transfer Matrix for Personnel	
5. Transfer Matrix for Materiel	
6. Personnel Required for Essential Teams	
7. Materiel Required for Essential Teams	
8. PD Set for Personnel	
9. PD Set for Materiel	
2. Output Data Results.	2.3.2.2
1. Capability at Selected Times	
2. Cumulative Area (Integral of Unit Capability) at Selected Times	
OPTIONAL RESULTS OUTPUT.	2.3.3
1. Choke Analysis Output: Sensitivity Analysis Needs and Surplus.	2.3.3.1
2. Multiple Optimal Solution (MOS) Output	2.3.3.2
3. Assignment Matrices Output	2.3.3.3
4. Mean Time Only Output.	2.3.3.4
5. Input Only Output.	2.3.3.5

Figure 2-18. AMORE Model Output

```
***** THIS IS AN INPUT CHECK RUN ONLY *****

          FLAGS ARE SET AS FOLLOWS
          0=NO    1=YES    >1=THAT NUMBER

          NUMBER OF ITERATIONS=  50

          CHOKE SENSITIVITY DATA 1

          ASSIGNMENT DATA 1

          ALTERNATE OPTIMAL SOLUTIONS 0

          USE MEAN TIMES ONLY 0


                              TIMES FOR CAPABILITY CALCULATIONS ARE:
  0.250     0.500     0.750     1.000     1.250     1.500     1.750     2.000     2.250     2.500
  2.750     3.000     3.250     3.500     3.750     4.000     4.250     4.500     4.750     5.000
  5.250     5.500     5.750     6.000
```

Figure 2-19. Input Data Printout

PERSONNEL DATA

	TASK NAME	INITIAL STRENGTH
1	COMPANY CO	1
2	COMPANY XO	1
3	FIRST SGT	1
4	SUPPLY SGT	1
5	TAC COM CH	1
6	ARMORER	1
7	CARRIER DR	20
8	RTO	6
9	SUPPLYMAN	1
10	MOTOR SGT	1
11	SR REC OP	1
12	SR TRK MEN	1
13	MAINT CLK	1
14	COM OP MEN	1
15	REC VEH OP	1
16	TRK MEN	5
17	R PLT LDR	3
18	R PLT SGT	3
19	A PLT SGT	3
20	SQUAD LDR	9
21	TEAM LDR	18
22	AUTO RIFLE	18
23	GRENADIER	18
24	RIFLEMAN	27
25	W PLT LDR	1
26	W PLT SGT	1
27	M SEC LDR	1
28	FDC COMPT	2
29	M SQD LDR	3
30	MORT GNNR	6
31	AMMO BEAR	3
32	AT SEC LDR	1
33	AT SQD LDR	1
34	TOW GNNR	2
35	ASST GNNR	2

Figure 2-19. Input Data Printout (Continued)

MATERIEL DATA

	TYPE NAME	INITIAL SUPPLY	LIGHT REPAIR TIME	MODERATE REPAIR TIME
1	CO CARRIER	1	60	240
2	XO CARRIER	1	60	240
3	1/4T HQ	1	45	180
4	1/4T TLR	1	15	90
5	2-1/2T SUP	1	45	180
6	1-1/2T TLR	1	15	90
7	RECOVERY V	1	60	240
8	2-1/2T AMT	2	45	180
9	1-1/2T TLR	1	15	90
10	PL CARRIER	3	60	240
11	SL CARRIER	9	60	240
12	1/4T W PLT	2	45	180
13	1/4T TLR	2	15	90
14	MG CARRIER	1	60	240
15	M CARRIER	3	60	240
16	T CARRIER	2	60	240
17	MG 7.62	15	30	180
18	DRAGON ATW	9	30	180
19	RIFLE 5.56	153	15	60

Figure 2-19. Input Data Printout (Continued)

TRANSFER MATRIX FOR PERSONNEL

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
1	0	0	0	30	.	.	0	0	0	.	30	.	30	.	10	.	0	0	0	0	0	0	0	0	0	0	0	15	0	15	0	0	0	10	0
2	0	0	0	30	.	.	0	0	0	.	30	.	30	.	10	.	0	0	0	0	0	0	0	0	0	0	0	15	0	15	0	0	0	10	0
3	15	0	0	30	.	.	0	0	0	10	30	.	30	.	10	.	0	0	0	0	0	0	0	0	30	15	15	15	0	15	0	0	0	10	0
4	.	.	60	0	.	0	.	0	0	.	.	.	10	.	.	10	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	10	20	5
5	.	.	60	30	0	.	.	0	0	.	.	.	10	0	.	10	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	10	20	5
6	.	.	.	30	.	0	.	10	0	.	.	.	10	.	.	10	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	.	30	5
7	.	.	.	.	.	.	0	0	10	.	30	.	.	.	10	30	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	.	.	5
8	.	.	.	.	.	.	.	0	10	.	.	.	.	30	.	.	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	.	.	5
9	.	.	.	60	.	30	.	10	0	.	.	.	10	.	.	.	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	.	.	5
10	.	.	60	30	.	30	0	0	0	0	0	0	0	.	0	0	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	10	20	5
11	.	.	.	.	.	.	0	0	0	30	0	30	10	.	0	0	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	.	.	5
12	.	.	.	.	.	30	0	0	0	30	10	0	10	.	0	0	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	.	.	5
13	.	.	.	60	.	.	.	10	0	.	.	.	0	.	.	10	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	.	.	5
14	.	.	.	.	30	.	.	0	10	.	.	.	30	0	.	10	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	.	.	5
15	.	.	.	.	.	.	0	0	10	60	10	60	30	.	0	.	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	.	.	5
16	.	.	.	.	.	60	0	10	10	.	30	30	30	.	10	0	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	.	.	5
17	30	15	15	30	.	.	0	0	0	.	30	.	30	.	10	.	0	0	0	0	0	0	0	0	10	0	0	15	0	15	0	0	0	10	0
18	60	30	30	.	.	.	0	0	0	.	30	.	30	.	10	.	0	0	0	0	0	0	0	0	30	15	15	30	0	15	0	0	0	10	0
19	.	.	.	.	.	.	0	0	0	.	30	.	30	.	10	.	30	10	0	0	0	0	0	0	60	30	30	.	0	15	0	0	10	30	0
20	.	.	.	.	.	.	0	0	0	.	.	.	.	.	.	.	.	30	10	0	0	0	0	0	.	.	.	.	.	.	0	30	10	30	5
21	.	.	.	.	.	.	0	0	0	.	.	.	.	.	.	.	.	60	30	10	0	0	0	0	.	.	.	.	.	.	0	.	.	.	5
22	.	.	.	.	.	.	10	10	10	.	.	.	.	.	.	.	.	.	.	.	10	0	0	0	.	.	.	.	.	.	0	.	.	.	5
23	.	.	.	.	.	.	10	10	10	.	.	.	.	.	.	.	.	.	.	.	10	0	0	0	.	.	.	.	.	.	0	.	.	.	5
24	.	.	.	.	.	.	10	10	10	.	.	.	.	.	.	.	.	.	.	.	30	0	0	0	.	.	.	.	.	.	0	.	.	.	5
25	30	15	15	30	.	.	0	0	0	10	30	.	30	.	10	.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
26	60	30	30	.	.	.	0	0	0	.	30	.	30	.	10	.	15	10	0	0	0	15	15	0	0	0	0	0	0	0	0	0	0	10	0
27	.	.	.	.	.	.	0	0	0	.	30	.	30	.	10	.	.	30	10	30	10	15	15	0	30	10	0	0	0	0	0	10	0	10	5
28	.	.	.	.	.	.	.	0	0	.	.	.	.	.	.	.	.	.	.	.	.	15	15	0	.	30	0	0	10	10	0	.	.	.	5
29	.	.	.	.	.	.	0	0	0	.	.	.	.	.	.	.	.	.	.	.	30	15	15	0	.	.	10	10	0	0	0	15	10	15	5
30	.	.	.	.	.	.	10	10	10	.	.	.	.	.	.	.	.	.	.	.	.	15	15	0	.	.	30	30	10	0	0	30	.	.	5
31	.	.	.	.	.	.	10	10	10	.	.	.	.	.	.	.	.	.	.	.	.	15	15	0	.	.	.	.	.	10	0	.	.	.	5
32	.	.	.	.	.	.	0	0	0	.	30	.	30	.	10	.	.	30	10	30	10	15	15	0	30	10	10	10	10	10	0	0	0	0	0
33	.	.	.	.	.	.	0	0	0	.	.	.	.	.	.	.	.	.	.	.	30	15	15	0	.	30	30	30	30	15	0	10	0	0	0
34	.	.	.	.	.	.	10	10	10	.	.	.	.	.	.	.	.	.	.	.	.	15	15	0	.	.	.	.	.	30	0	10	0	0	0
35	.	.	.	.	.	.	10	10	10	.	.	.	.	.	.	.	.	.	.	.	.	15	15	0	.	.	.	.	.	.	0	.	10	0	0

Figure 2-19. Input Data Printout (Continued)

TRANSFER MATRIX FOR MATERIAL

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	0	0	0	.	30	.	.	30	.	0	0	0	.	0	30	.	.	.	.
2	0	0	0	.	30	.	.	30	.	0	0	0	.	0	30	.	.	.	.
3	.	.	0	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.	.
4	.	.	.	0	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.
5	.	.	30	.	0	.	.	10	.	.	.	30	.	.	.	.	.	.	.
6	.	.	.	.	.	0	.	.	0	.	.	.	.	.	.	.	.	.	.
7	.	.	10	.	.	.	0	.	.	.	.	10	.	.	.	.	.	.	.
8	.	.	30	.	10	.	.	0	.	.	.	30	.	.	.	.	.	.	.
9	.	.	.	.	.	0	.	.	0	.	.	.	.	.	.	.	.	.	.
10	10	10	0	.	30	.	.	30	.	0	0	0	.	0	30	.	.	.	.
11	10	10	0	.	30	.	.	30	.	0	0	0	.	0	30	.	.	.	.
12	.	.	10	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.	.
13	.	.	.	0	.	.	.	.	.	.	.	.	0	.	.	.	.	.	.
14	30	30	0	.	30	.	.	30	.	10	0	0	.	0	30	.	.	.	.
15	30	30	0	.	30	.	.	30	.	30	30	0	.	0	0	.	.	.	.
16	30	30	0	.	.	.	.	.	.	.	.	0	.	0	.	0	.	.	.
17	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	.	.
18	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0	.
19	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	0

Figure 2-19. Input Data Printout (Continued)

PERSONNEL REQUIRED FOR MISSION 1

TASKS	ESSENTIALS FOR TEAM 1	ESSENTIALS FOR TEAM 2	ESSENTIALS FOR TEAM 3	ESSENTIALS FOR TEAM 4	ESSENTIALS FOR TEAM 5	ESSENTIALS FOR TEAM 6	ESSENTIALS FOR TEAM 7	ESSENTIALS FOR TEAM 8
1	0	0	0	0	0	0	1	1
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	1	2	3	4	5	6	7	8
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	1	1
11	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	1	1
16	0	0	0	0	0	0	2	2
17	0	0	1	1	1	1	1	1
18	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0
20	0	1	1	2	2	3	3	4
21	1	2	3	4	5	6	7	8
22	1	2	3	4	5	6	7	8
23	1	2	3	4	5	6	7	8
24	1	2	3	4	5	6	7	8
25	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0
29	0	0	0	0	1	1	1	1
30	0	0	0	0	2	2	2	2
31	0	0	0	0	0	0	0	0
32	0	1	1	1	1	1	1	1
33	0	0	0	0	0	0	0	0
34	0	1	1	1	1	1	1	1
35	0	0	0	0	0	0	0	0

NOTE: Input is the increase of requirement from previous team. The model output above is the cumulative requirement at each team level.

Figure 2-19. Input Data Printout (Continued)

PERSONNEL REQUIRED FOR MISSION 1

TASKS	ESSENTIALS FOR TEAM 9	ESSENTIALS FOR TEAM 10	ESSENTIALS FOR TEAM 11	ESSENTIALS FOR TEAM 12	ESSENTIALS FOR TEAM 13	ESSENTIALS FOR TEAM 14	ESSENTIALS FOR TEAM 15	ESSENTIALS FOR TEAM 16
1	1	1	1	1	1	1	1	1
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	9	10	11	12	13	14	15	16
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
10	1	1	1	1	1	1	1	1
11	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0
15	1	1	1	1	1	1	1	1
16	2	2	2	2	2	2	2	2
17	2	2	2	2	2	2	3	3
18	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0
20	4	5	5	6	6	7	7	8
21	9	10	11	12	13	14	15	16
22	9	10	11	12	13	14	15	16
23	9	10	11	12	13	14	15	16
24	9	10	11	12	13	14	15	16
25	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0
27	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0
29	1	1	1	1	2	2	2	2
30	2	2	2	2	4	4	4	4
31	0	0	0	0	0	0	0	0
32	1	1	1	1	1	1	1	1
33	0	0	1	1	1	1	1	1
34	1	1	2	2	2	2	2	2
35	0	0	0	0	0	0	0	0

NOTE: Input is the increase of requirement from previous team. The model output above is the cumulative requirement at each team level.

Figure 2-19. Input Data Printout (Continued)

PERSONNEL REQUIRED FOR MISSION 1

TASKS	ESSENTIALS FOR TEAM 17	ESSENTIALS FOR TEAM 18
1	1	1
2	0	0
3	0	0
4	0	0
5	0	0
6	0	0
7	17	18
8	0	0
9	0	0
10	1	1
11	0	0
12	0	0
13	0	0
14	0	0
15	1	1
16	2	2
17	3	3
18	0	0
19	0	0
20	8	9
21	17	18
22	17	18
23	17	18
24	17	18
25	0	0
26	0	0
27	0	0
28	0	0
29	3	3
30	6	6
31	0	0
32	1	1
33	1	1
34	2	2
35	0	0

NOTE: Input is the increase of requirement from previous team. The model output above is the cumulative requirement at each team level.

Figure 2-19. Input Data Printout (Continued)

MATERIFL REQUIRED FOR MISSION 1

TASKS	ESSENTIALS FOR TEAM 1	ESSENTIALS FOR TEAM 2	ESSENTIALS FOR TEAM 3	ESSENTIALS FOR TEAM 4	ESSENTIALS FOR TEAM 5	ESSENTIALS FOR TEAM 6	ESSENTIALS FOR TEAM 7	ESSENTIALS FOR TEAM 8
1	0	0	0	0	0	0	1	1
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	1	1
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
10	0	0	1	1	1	1	1	1
11	1	1	1	2	2	3	3	4
12	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0
15	0	0	0	0	1	1	1	1
16	0	1	1	1	1	1	1	1
17	1	1	2	3	3	4	5	6
18	0	1	1	2	2	3	3	4
19	5	13	19	25	33	39	47	53

NOTE: Input is the increase of requirement from previous team. The model output above is the cumulative requirement at each team level.

Figure 2-19. Input Data Printout (Continued)

MATERIEL REQUIRED FOR MISSION 1

TASKS	ESSENTIALS FOR TEAM 9	ESSENTIALS FOR TEAM 10	ESSENTIALS FOR TEAM 11	ESSENTIALS FOR TEAM 12	ESSENTIALS FOR TEAM 13	ESSENTIALS FOR TEAM 14	ESSENTIALS FOR TEAM 15	ESSENTIALS FOR TEAM 16
1	1	1	1	1	1	1	1	1
2	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	1	1	1	1	1	1	1	1
8	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0
10	2	2	2	2	2	2	3	3
11	4	5	5	6	6	7	7	8
12	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0
15	1	1	1	1	2	2	2	2
16	1	1	2	2	2	2	2	2
17	7	8	8	9	9	10	11	12
18	4	5	5	6	6	7	7	8
19	59	65	72	78	86	92	98	104

<u>NOTE</u>: Input is the <u>increase</u> of requirement from previous team. The model outout above is the <u>cumulative</u> requirement at each team level.

Figure 2-19. Input Data Printout (Continued)

MATERIEL REQUIRED FOR MISSION 1

TASKS	ESSENTIALS FOR TEAM 17	ESSENTIALS FOR TEAM 18
1	1	1
2	0	0
3	0	0
4	0	0
5	0	0
6	0	0
7	1	1
8	0	0
9	0	0
10	3	3
11	8	9
12	0	0
13	0	0
14	0	0
15	3	3
16	2	2
17	12	13
18	8	9
19	112	118

NOTE: Input is the increase of requirement from previous team. The model output above is the cumulative requirement at each team level.

Figure 2-19. Input Data Printout (Continued)

DAMAGE PROBABILITIES FOR SET 1
THE MECHANIZED INFANTRY COMPANY CONDUCTING THE ATTACK MISSION

PERSONNEL DAMAGE LEVELS BY TASK

INDEX	TASK NAME	DELAY(MINUTES)	DAMAGE PROBABILITY(*)
1	COMPANY CO	5	.1500
2	COMPANY XO	5	.1300
3	FIRST SGT	5	.1300
4	SUPPLY SGT	5	.1300
5	TAC COM CH	5	.1300
6	ARMORER	5	.1300
7	CARRIER DR	5	.1800
8	RTO	5	.1300
9	SUPPLYMAN	5	.1300
10	MOTOR SGT	5	.1500
11	SR REC OP	5	.1300
12	SR TRK MEN	5	.1300
13	MAINT CLK	5	.1300
14	COM OP MEN	5	.1300
15	REC VEH OP	5	.1500
16	TRK MEN	5	.1500
17	R PLT LDR	5	.1800
18	R PLT SGT	5	.1300
19	A PLT SGT	5	.1300
20	SQUAD LDR	5	.1800
21	TEAM LDR	5	.1800
22	AUTO RIFLE	5	.1800
23	GRENADIER	5	.1800
24	RIFLEMAN	5	.1800
25	M PLT LDR	5	.1300
26	M PLT SGT	5	.1300
27	M SEC LDR	5	.1400
28	FDC COMPT	5	.1300
29	M SQD LDR	5	.1400
30	MORT GNNR	5	.1400
31	AMMO BEAR	5	.1300
32	AT SEC LDR	5	.1800
33	AT SQD LDR	5	.1800
34	TOW GNNR	5	.1800
35	ASST GNNR	5	.1800

Figure 2-19. Input Data Printout (Continued)

MATERIEL DAMAGE LEVELS BY TYPE

INDEX	TYPE NAME	DELAY(MINUTES)	CUMULATIVE DAMAGE(%) LIGHT	MODERATE	SEVERE	NONCUMULATIVE DAMAGE(%) LIGHT	MODERATE	SEVERE
1	CO CARRIER	10	.300	.220	.080	.080	.140	.080
2	XO CARRIER	10	.270	.190	.060	.080	.130	.060
3	1/4T MG	10	.270	.190	.060	.080	.130	.060
4	1/4T TLR	10	.270	.190	.060	.080	.130	.060
5	2-1/2T SUP	10	.270	.190	.060	.080	.130	.060
6	1-1/2T TLR	10	.270	.190	.060	.080	.130	.060
7	RECOVERY V	10	.300	.220	.080	.080	.140	.080
8	2-1/2T MNT	10	.270	.190	.060	.080	.130	.060
9	1-1/2T TLR	10	.270	.190	.060	.080	.130	.060
10	PL CARRIER	10	.350	.250	.120	.100	.130	.120
11	SL CARRIER	10	.350	.250	.120	.100	.130	.120
12	1/4T W PLT	10	.270	.190	.060	.080	.130	.060
13	1/4T TLR	10	.270	.190	.060	.080	.130	.060
14	HQ CARRIER	10	.270	.190	.060	.080	.130	.060
15	M CARRIER	10	.280	.200	.080	.080	.120	.080
16	T CARRIER	10	.350	.250	.120	.100	.130	.120
17	MG 7.62	10	.350	.250	.120	.100	.130	.120
18	DRAGON ATW	10	.350	.250	.120	.100	.130	.120
19	RIFLE 5.56	10	.350	.250	.120	.100	.130	.120

Figure 2-19. Input Data Printout (Continued)

2.3.2.2 Results

The second portion of the standard output consists of two forms of the end of run statistics for each mission. The first, shown in Figure 2-20, contains the mean fraction of capability for personnel and materiel. These capabilities are evaluated at each of the user's specified time slices, and at zero, minimum, and infinite times. The unit capability, labelled "minimum" on the printout because it is the average for all iterations of the minimum of the personnel and materiel capabilities, is also included. To illustrate how to read the output, note that after 0.75 hours, personnel regained a mean capability of 100 percent, while materiel reached only a mean capability of 42.9 percent with minimum or unit mean capability being 42.9 percent at that time. A 90 percent confidence limit is also shown for each of the mean capabilities.

The second form (Figure 2-21) contains information on the average cumulative area under the unit capability curve (the integral of unit capability with respect to time). This area is presented in terms of unit hours and team hours available from the start of reorganizations to the time of interest. For example, a full-up unit at 100 percent capability would have one unit hour available in one hour. If that unit had ten teams it would have ten team hours available in one hour. The example case has only 0.389 unit hours available in the first hour or only 7.005 team hours from an eighteen team unit. The unit is shown to have recovered to 46.6% capability at the end of the first hour. However, the potential work the unit could have produced in that hour is only 38.9% of a full up unit. By the same token at the end of six hours the unit has recovered to 70.3% capability but in that time had the potential to perform only (3.478/6.0 X 100 or 62.610/(6 X 18) X 100) 57.9% of the work a full unit could do.

TWO MECHANIZED INFANTRY COMPANY CONDUCTING THE ATTACK MISSION
MEAN CAPABILITIES

TIME (HOURS)	MISSION 1 PERSONNEL		MATERIEL		TOTAL	
0.000	.441	.059	.343	.043	.253	.043
MINIMUM	.436	.061	.343	.043	.252	.043
0.250	.657	.054	.384	.046	.362	.046
0.500	.992	.046	.407	.050	.407	.050
0.750	1.000	.000	.429	.051	.429	.051
1.000	1.000	.000	.466	.051	.466	.051
1.250	1.000	.000	.496	.053	.496	.053
1.500	1.000	.000	.529	.056	.529	.056
1.750	1.000	.000	.539	.058	.539	.058
2.000	1.000	.000	.562	.053	.562	.053
2.250	1.000	.000	.578	.056	.578	.056
2.500	1.000	.000	.591	.055	.591	.055
2.750	1.000	.000	.611	.052	.611	.052
3.000	1.000	.000	.613	.052	.613	.052
3.250	1.000	.000	.617	.053	.617	.053
3.500	1.000	.000	.619	.053	.619	.053
3.750	1.000	.000	.622	.054	.622	.054
4.000	1.000	.000	.632	.053	.632	.053
4.250	1.000	.000	.647	.054	.647	.054
4.500	1.000	.000	.657	.055	.657	.055
4.750	1.000	.000	.660	.054	.660	.054
5.000	1.000	.000	.664	.055	.664	.055
5.250	1.000	.000	.669	.055	.669	.055
5.500	1.000	.000	.703	.055	.703	.055
5.750	1.000	.000	.703	.055	.703	.055
6.000	1.000	.000	.703	.055	.703	.055
INFINITY	1.000	.000	.759	.051	.759	.051

ITERATIONS 50

TWO SIDED 90 PERCENT CONFIDENCE LIMITS ARE TO THE RIGHT OF EACH COLUMN

Figure 2-20. Unit Capability Over Time

CUMULATIVE AREA
TIME VERSUS TEAMS BUILT

MISSION 1

TIME (HOURS)	UNIT CAPABILITY	UNIT HOURS	TEAM HOURS
MINIMUM	0.252	0.000	0.000
0.250	0.362	0.077	1.383
0.500	0.407	0.173	3.113
0.750	0.429	0.277	4.993
1.000	0.466	0.389	7.005
1.250	0.496	0.509	9.168
1.500	0.529	0.637	11.473
1.750	0.539	0.771	13.875
2.000	0.562	0.908	16.353
2.250	0.578	1.051	18.918
2.500	0.591	1.197	21.548
2.750	0.611	1.347	24.253
3.000	0.613	1.500	27.008
3.250	0.617	1.654	29.775
3.500	0.619	1.809	32.555
3.750	0.622	1.964	35.348
4.000	0.632	2.121	38.170
4.250	0.647	2.280	41.048
4.500	0.657	2.443	43.980
4.750	0.680	2.610	46.988
5.000	0.684	2.781	50.058
5.250	0.689	2.953	53.148
5.500	0.703	3.127	56.280
5.750	0.703	3.303	59.445
6.000	0.703	3.478	62.610

Figure 2-21. Integral of Unit Capability Over Time

These two outputs therefore provide the analyst different means of evaluating unit capability as a function of time. Which of them and how they are used is dependent on the problem at hand and the analysts' choice for evaluating and presenting results.

2.3.3 Optional Results Output

2.3.3.1 Choke analysis output

A choke analysis is performed for each iteration resulting in a maximum number of teams less than the total number of teams. This analysis ascertains the personnel skill groups and equipment type which would have been needed in order to build one more team. The output is labelled "Sensitivity Analysis Needs and Surplus" and it includes the average needs, the average surplus, and the standard deviation of these averages. The number of the team attempted (one beyond the optimal solution team) is given at the top of the page and the number of iterations for which this 'next' team was attempted appears at the bottom.

Figure 2-22 is an example of Choke Analysis Output for materiel. It shows that the sixteenth team was attempted seven times using "dummy" resources following a like number of optimal solutions resulting in a maximum capability of fifteen teams. Note that a lack of materiel items 17 and 18 caused this to happen. On the average,team 16 required 0.14 of "dummy" item 17, the MG 7.62. However, an average of 0.86 "dummy" DRAGON, item 18, was required. In other words, in one of the seven iterations a MG 7.62 was needed to build the sixteenth team while the remaining six iterations required a DRAGON.

For those iterations where the total number of teams (eighteen in this case) can be built, the "next" team increment solution is not

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MISSION 1
MATERIEL

	TEAM 15				TEAM 16			
	NEEDS		SURPLUS		NEEDS		SURPLUS	
TYPE	AVERAGE	ST. DEVIATION	AVERAGE	ST. DEVIATION	AVERAGE	ST. DEVIATION	AVERAGE	ST. DEVIATION
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.71	0.49
4	0.00	0.00	1.00	0.00	0.00	0.00	0.86	0.38
5	0.00	0.00	1.00	0.00	0.00	0.00	0.57	0.53
6	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	1.00	0.00	0.00	0.00	1.14	0.69
9	0.00	0.00	0.00	0.00	0.00	0.00	0.71	0.49
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	1.00	0.00	0.00	0.00	1.43	0.53
13	0.00	0.00	1.00	0.00	0.00	0.00	1.43	0.53
14	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.38
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	1.00	0.00	0.00	0.00	0.14	0.38	0.00	0.00
18	0.00	0.00	0.00	0.00	0.86	0.38	0.00	0.00
19	0.00	0.00	6.00	0.00	0.00	0.00	1.00	1.73
LIGHT								
1	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.38
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.38
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.49
9	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.38
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.38
13	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.49
14	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.76
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	10.00	0.00	0.00	0.00	12.57	3.82
MODERATE								
1	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	1.00	0.00	0.00	0.00	0.14	0.38
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	1.00	0.00	0.00	0.00	0.29	0.76
9	0.00	0.00	1.00	0.00	0.00	0.00	0.14	0.38
10	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.38
11	0.00	0.00	1.00	0.00	0.00	0.00	0.86	1.21
12	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.49
13	0.00	0.00	1.00	0.00	0.00	0.00	0.29	0.49
14	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.38
15	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	1.57	1.51
18	0.00	0.00	1.00	0.00	0.00	0.00	0.14	0.38
19	0.00	0.00	13.00	0.00	0.00	0.00	18.29	2.21
	NUMBER OF ITERATIONS 1.				NUMBER OF ITERATIONS 7.			

Figure 2-22. Choke Analysis Data - Teams 15 & 16

required. Therefore, the needs are not necessary and only a tally of average surplus and standard deviation of surplus is printed (Figure 2-23). Those surpluses are labelled "AFTER LAST TEAM".

The results discussed above account for only twelve of the fifty iterations of the simulation. Figure 2-22 & 2-23 actually show thirteen iterations. One iteration choke on team fifteen, seven iterations choked at team sixteen, and five iterations where all eighteen materiel teams were completed. Examination of the full output from this run shows the following additional distribution of results for materiel; six iterations only six materiel teams could be built, eight iterations ten teams were built, one iteration eleven teams were built, six iterations thirteen teams were built, three iterations sixteen teams were built and thirteen iterations seventeen teams were built. For materiel, this then accounts for all fifty of the iterations of this run (6+8+1+6 +1+7+3+13+5). The results for personnel were significantly different, for in all fifty iterations the unit was able to reconstitute all eighteen personnel teams with the surviving personnel.

2.3.3.2 Multiple optimal solution (MOS) output

The multiple optimal solution option provides the ability to examine each of the "choke" solutions for alternate optimal solutions. A sample of the output provided when this option is exercised is provided at Figure 2-24. The MOS output is directly comparable to choke analysis output with the same team number. In the sample case, six more solutions than the number of iterations were found. In cases with multiple solutions, average needs and surpluses may vary a great deal between the MOS and the choke analysis output. When no other solutions are found, the number of iterations equals the number of solutions and a comparison of the average needs and surpluses in the two figures shows exactly the same results.

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MISSION 1
MATERIEL

AFTER LAST TEAM

TYPE	SURPLUS AVERAGE	SURPLUS ST. DEVIATION
1	0.00	0.00
2	0.00	0.00
3	0.60	0.55
4	0.80	0.45
5	0.80	0.45
6	0.80	0.45
7	0.00	0.00
8	1.60	0.55
9	0.80	0.45
10	0.00	0.00
11	0.00	0.00
12	1.40	0.89
13	2.00	0.00
14	0.00	0.00
15	0.00	0.00
16	0.00	0.00
17	0.00	0.00
18	0.00	0.00
19	0.00	0.00
LIGHT		
1	0.00	0.00
2	0.00	0.00
3	0.00	0.00
4	0.00	0.00
5	0.00	0.00
6	0.00	0.00
7	0.00	0.00
8	0.20	0.45
9	0.00	0.00
10	0.00	0.00
11	0.00	0.00
12	0.00	0.00
13	0.00	0.00
14	0.00	0.00
15	0.00	0.60
16	0.00	0.00
17	0.20	0.45
18	0.00	0.00
19	0.60	1.34
MODERATE		
1	0.00	0.00
2	0.00	0.00
3	0.40	0.55
4	0.00	0.00
5	0.00	0.00
6	0.20	0.45
7	0.00	0.00
8	0.00	0.00
9	0.00	0.00
10	0.00	0.00
11	0.20	0.45
12	0.40	0.89
13	0.00	0.00
14	0.00	0.00
15	0.00	0.00
16	0.00	0.00
17	0.80	0.45
18	0.00	0.00
19	11.80	4.66

NUMBER OF ITERATIONS 5.

Figure 2-23. Choke Analysis Data for Cases When All Teams Completed

SENSITIVITY ANALYSIS NEEDS AND SURPLUS CONTINUED
MISSION 1
MATERIEL

YEAR 15

TYPE	NEEDS MINIMUM	NEEDS AVERAGE	NEEDS MAXIMUM	NEEDS ST. DEVIATION	SURPLUS MINIMUM	SURPLUS AVERAGE	SURPLUS MAXIMUM	SURPLUS ST. DEVIATION
1	0.00	0.03	1.00	0.11	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.77	1.00	0.44
4	0.00	0.00	0.00	0.00	0.00	0.85	1.00	0.38
5	0.00	0.00	0.00	0.00	0.00	0.77	1.00	0.44
6	0.00	0.00	0.00	0.00	0.00	0.62	1.00	0.51
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	1.38	2.00	0.77
9	0.00	0.00	0.00	0.00	0.00	0.77	1.00	0.44
10	0.00	0.09	1.00	0.19	0.00	0.00	0.00	0.00
11	0.00	0.11	1.00	0.21	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	1.46	2.00	0.66
13	0.00	0.00	0.00	0.00	0.00	1.38	2.00	0.65
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.08	1.00	0.28	0.00	0.00	0.00	0.00
18	0.00	0.85	1.00	0.38	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
LIGHT								
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.08	1.00	0.28
4	0.00	0.00	0.00	0.00	0.00	0.08	1.00	0.28
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.08	1.00	0.28
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.15	2.00	0.55
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.15	1.00	0.38
13	0.00	0.00	0.00	0.00	0.00	0.15	1.00	0.38
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.38	3.00	0.96
MODERATE								
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.08	1.00	0.28
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.23	1.00	0.44
6	0.00	0.00	0.00	0.00	0.00	0.23	1.00	0.44
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.46	2.00	0.66
9	0.00	0.00	0.00	0.00	0.00	0.15	1.00	0.38
10	0.00	0.00	0.00	0.00	0.00	0.08	1.00	0.28
11	0.00	0.00	0.00	0.00	0.00	0.15	1.00	0.38
12	0.00	0.00	0.00	0.00	0.00	0.23	1.00	0.44
13	0.00	0.00	0.00	0.00	0.00	0.23	1.00	0.44
14	0.00	0.00	0.00	0.00	0.00	0.23	1.00	0.44
15	0.00	0.00	0.00	0.00	0.00	0.08	1.00	0.28
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.69	2.00	0.63
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	10.00	16.31	22.00	4.25

NUMBER OF ITERATIONS 13.
TOTAL SOLUTIONS CONSIDERED 19.

Figure 2-24. Choke Analysis Data-Alternate Optimal Solution Format

The minimum and maximum values are derived considering all solutions found. The averages result from averaging all solutions found on each iteration and when all iterations are complete an average per iteration is calculated. This results in a weighted average solution where a solution with no alternates is weighted heavier than one with several alternates.

2.3.3.3 Assignment matrices output

Assignment matrices for each mission consist of the average assignment of survivors for those iterations used to build a particular maximum number of teams. For example Figure 2-25 depicts the average assignment of materiel resources which built a maximum of fifteen teams. Note that this solution occurred seven times. The seven iterations represented here are the same as those in Figure 2-22. The assignment matrix, Figure 2-25, shows how the surviving materiel items, both undamaged and repairable, were allocated to construct fifteen teams. The two columns to the far right summarize the unassigned (SURPLUS) and the TOTAL (assigned and SURPLUS) resources surviving per row. The choke analysis, Figure 2-22, shows what additional materiel items would have been required to construct sixteen teams with those same surviving assets.

A great deal of information can be gleaned from each one of the assignment matrices. To illustrate this, two representative samples, materiel items 2 and 16 in Figure 2-25 are examined to reveal the type of information that can be extracted for analysis purposes.

A look at materiel item 2 (XO Carrier) (which is not required in the fifteenth essential materiel team) shows that an average of 0.29 (out of one) of them was substituted for materiel item 1 (CO Carrier). Also, an average of 0.14 (out of one) XO Carriers is

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MISSION 1
MATERIAL

TEAM 15

TYPE	1	2	3	4	5	6	7	8	9	10	11	12	13
1	0.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.14	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.29	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.43	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.00
LIGHT													
1	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.57	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MODERATE													
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Figure 2-25. Assignment Data for Build of Fifteen Teams

TYPE	14	15	16	17	18	19	SURPLUS	TOTAL	
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.57	1
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.57	2
3	0.00	0.00	0.00	0.00	0.00	0.00	0.71	0.71	3
4	0.00	0.00	0.00	0.00	0.00	0.00	0.86	0.86	4
5	0.00	0.00	0.00	0.00	0.00	0.00	0.57	0.57	5
6	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	6
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71	7
8	0.00	0.00	0.00	0.00	0.00	0.00	1.14	1.14	8
9	0.00	0.00	0.00	0.00	0.00	0.00	0.71	0.71	9
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	10
11	0.00	0.00	0.00	0.00	0.00	0.00	0.14	5.43	11
12	0.00	0.00	0.00	0.00	0.00	0.00	1.43	1.43	12
13	0.00	0.00	0.00	0.00	0.00	0.00	1.43	1.43	13
14	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.71	14
15	0.00	1.86	0.00	0.00	0.00	0.00	0.14	2.29	15
16	0.00	0.00	1.14	0.00	0.00	0.00	0.00	1.14	16
17	0.00	0.00	0.00	7.14	0.00	0.00	0.14	9.29	17
18	0.00	0.00	0.00	0.00	5.86	0.00	0.00	5.86	18
19	0.00	0.00	0.00	0.00	0.00	97.86	5.29	103.14	19
LIGHT									
1	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.86	1
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.57	2
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71	3
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.86	4
5	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.71	5
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	6
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71	7
8	0.00	0.00	0.00	0.00	0.00	0.00	0.29	1.43	8
9	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.86	9
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	10
11	0.00	0.00	0.00	0.00	0.00	0.00	0.14	6.43	11
12	0.00	0.00	0.00	0.00	0.00	0.00	0.14	1.57	12
13	0.00	0.00	0.00	0.00	0.00	0.00	0.29	1.71	13
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71	14
15	0.00	0.14	0.00	0.00	0.00	0.00	0.14	2.57	15
16	0.00	0.00	0.14	0.00	0.00	0.00	0.00	1.29	16
17	0.00	0.00	0.00	1.57	0.00	0.00	0.29	11.14	17
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.86	18
19	0.00	0.00	0.00	0.00	0.00	0.14	14.29	117.57	19
MODERATE									
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.86	1
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.86	2
3	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.86	3
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.86	4
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.71	5
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	6
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	7
8	0.00	0.00	0.00	0.00	0.00	0.00	0.29	1.71	8
9	0.00	0.00	0.00	0.00	0.00	0.00	0.14	1.00	9
10	0.00	0.00	0.00	0.00	0.00	0.00	0.14	2.29	10
11	0.00	0.00	0.00	0.00	0.00	0.00	1.14	7.86	11
12	0.00	0.00	0.00	0.00	0.60	0.00	0.29	1.86	12
13	0.00	0.00	0.00	0.00	0.00	0.00	0.29	2.00	13
14	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.[illegible]	14
15	0.00	0.00	0.00	0.00	[illegible]	0.00	0.14	2.[illegible]	15
16	0.00	0.00	0.71	0.00	[illegible]	[illegible]	0.00	2.[illegible]	16
17	0.00	0.00	0.00	0.29	[illegible]	0.00	2.29	13.[illegible]	17

Number of iterations 7.

Figure 2-25. Assignment Data for Build of Fifteen Teams (Cont'd) substituted for materiel type 10 (PL Carrier) and an average of 0.14 (out of one) is substituted for materiel type 11 (SL Carrier). Additionally, an average of 0.29 XO carriers were substituted for materiel type 10 even after suffering moderate damage. An examination of the TOTAL column through the moderate damage level reveals that only an average of 0.86 XO Carriers survived altogether. This indicates that an average of 0.14 XO Carriers suffered at least severe damage and could not be used.

Recall that two TOW Carriers (materiel type 16) are required by the fifteenth essential materiel team. A close examination of the assignment matrix shows that an average of 1.14 (1.14/2 = 0.57 or 57 percent of the time) TOW Carriers survived undamaged and remained assigned to the original task. An inspection of the diagonal elements of the light and moderate damage matrices reveals that TOW carriers were damaged, repaired and returned to the unit. Of these reassigned TOW carriers 0.14 (seven percent) suffered light damage and about 0.71 (36 percent suffered moderate damage. Note that the TOTAL column through the moderate damage level reveals that an average of 2.00 (one-hundred percent) TOW carriers survived.

2.3.3.4 Mean time only output

The general method for determining operational time of an asset is to use a random exponential sampling of time based on the input mean or expected times. The mean time only option can be used to eliminate the exponential random sampling of time in the simulation. Figure 2-26 is an example which is directly comparable to Figure 2-20. A comparison of these figures shows the effect of the random sampling of time. Examination of the minimum, or unit, capability column shows that the values are equal at 0.00, minimum, and infinite times. This can be true only if the survivors, or casualties and damage, are the same for all iterations of both runs. The AMORE model is designed to

THE MECHANIZED INFANTRY COMPANY CONDUCTING THE ATTACK MISSION
MEAN CAPABILITIES

TIME (HOURS)	MISSION 1 PERSONNEL		MATERIEL		MINIMUM	
0.000	.441	.059	.343	.043	.258	.043
MINIMUM	.436	.061	.343	.043	.252	.043
0.250	.987	.022	.364	.045	.364	.045
0.500	.987	.022	.368	.046	.368	.046
0.750	1.000	.000	.386	.049	.386	.049
1.000	1.000	.000	.386	.049	.386	.049
1.250	1.000	.000	.484	.050	.484	.050
1.500	1.000	.000	.484	.050	.484	.050
1.750	1.000	.000	.488	.051	.488	.051
2.000	1.000	.000	.488	.051	.488	.051
2.250	1.000	.000	.488	.051	.488	.051
2.500	1.000	.000	.488	.051	.488	.051
2.750	1.000	.000	.488	.051	.488	.051
3.000	1.000	.000	.488	.051	.488	.051
3.250	1.000	.000	.517	.058	.517	.058
3.500	1.000	.000	.517	.058	.517	.058
3.750	1.000	.000	.517	.058	.517	.058
4.000	1.000	.000	.517	.058	.517	.058
4.250	1.000	.000	.758	.051	.758	.051
4.500	1.000	.000	.758	.051	.758	.051
4.750	1.000	.000	.759	.051	.759	.051
5.000	1.000	.000	.759	.051	.759	.051
5.250	1.000	.000	.759	.051	.759	.051
5.500	1.000	.000	.759	.051	.759	.051
5.750	1.000	.000	.759	.051	.759	.051
6.000	1.000	.000	.759	.051	.759	.051
INFINITY	1.000	.000	.759	.051	.759	.051

ITERATIONS 50

TWO SIDED 90 PERCENT CONFIDENCE LIMITS ARE TO THE RIGHT OF EACH COLUMN

Figure 2-26. Unit Capability Over Time Using Input Mean Times give this result, that is, provide the same random number string for casualty assessment when the mean time only option is used. (Any cnanges in data are likely to result in a different random number string and thus a different casualty assessment). This allows a direct comparison of the effect of a distribution of times. Further examination of the two outcomes shows a much steeper recovery at early times and a much shallower recovery at the later times when a distribution of times is sampled. When the mean times are used directly, maximum recovery is accomplished between 4.5 and 4.75 hours. When the distribution is sampled, recovery is not complete until some time after 6.0 hours.

2.3.3.5 Input only output

A printout of all input data can be obtained without analyzing the data by using the input only option. A sample printout was included in Section 2.3.2.1, Figure 2-19.

2.4 INPUT AND OUTPUT ANALYSIS

2.4.1 Introduction

The remainder of this chapter provides more detailed discussions of the input development process and of the output analysis and its uses. The discussions included assume a familiarity with the foregoing material and a basic understanding of the AMORE concepts.

Figure 2-27 depicts the major steps required in the exercise of the AMORE methodology. The figure clearly shows the required level of effort on the user's part prior to any model action. The figure does not provide an appreciation of the analytical requirements following a model run, i.e., output analysis. There is no simple or general way to express that requirement. The analysis of output is determined by the problem which is being addressed and may range from direct use of the model output from a few runs to complicated combinations and manipulations of data produced by many AMORE runs.

2.4.2 Input Development

The input data requirements for the AMORE model are summarized below:

1. Significant personnel skills list.
2. Significant materiel items list.
3. Initial authorized (TOE or other start point) quantities for both personnel and materiel.
4. Personnel skill transferability matrix.
5. Personnel skill requirements for the mission essential teams.
6. Materiel item transferability matrix.

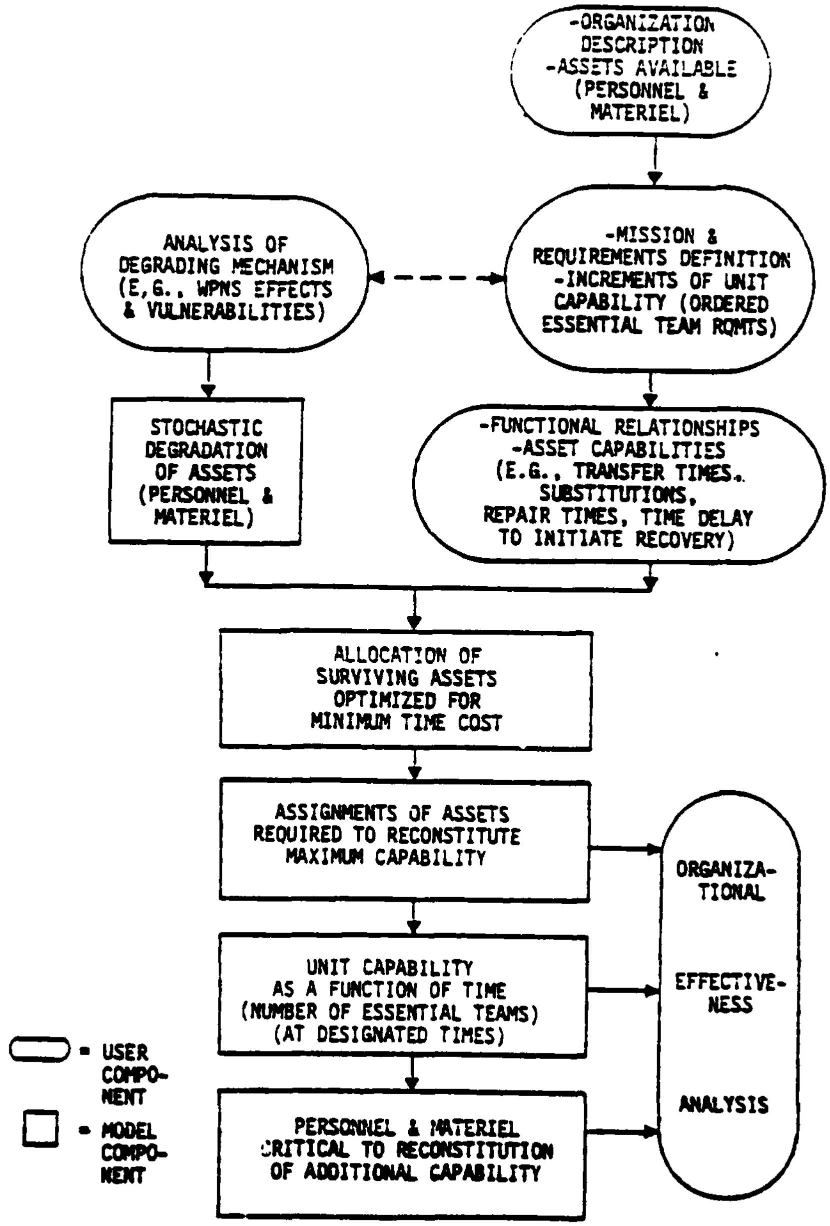

Figure 2-27. The AMORE Process - Analytical Implications

7. Materiel item requirements for the mission essential teams.
8. Damage and/or loss probabilities.
9. Damage rapair times for materiel items.
10. Commanders decision or delay time prior to reorganization.
11. Time specification for capability assessment.

The development of this data can be classified into two major categories of analysis; the unit analysis and the analysis of the degrading mechanism. The remainder of this section will be devoted to a discussion of these two areas of analysis.

2.4.3 Unit Analysis

Unit analysis may be generally divided into eight steps.

1. Problem definition.
2. Identify Data Sources.
3. Functional Analysis.
4. Select Significant Personnel Skills.
5. Develop Skill Substitution Matrix.
6. Select Significant Equipment Items.
7. Develop Equipment Substitution Matrix.
8. Develop Mission Essential Teams.

The first three steps are recommended in the order given. The remaining steps are highly interrelated and each step will require consideration of all others so that the order of listing has little significance.

2.4.3.1 Problem definition

The first step of any analysis must be to define the problem. The unit(s) to be analyzed must be defined first. The purpose of the analysis must then be clearly defined so that the questions being asked are understood and the answers to those questions can be formulated as the problem solution. The scenario must be defined and all scenario factors must be considered. This will define the degrading or damage mechanism(s) to be applied to the unit and is also required for definition of the unit mission/posture(s) to be examined.

2.4.3.2 Identify and Gather Data

There are many data sources which are useful and/or necessary for the unit analysis. The list below is representative and is not intended to be all inclusive. It has been found that personal experience from duty in a particular or similar organization is extremely valuable to the AMORE process.

1. Study Directive
2. Table of Organization and Equipment (TOE)
3. Field Manuals
4. Training Circulars
5. Army Regulations (570-2, 611-201, etc.)
6. Common Tables of Allowance
7. TRADOC/Service Schools
8. DA Staff
9. DARCOM
10. Theater Regulations
11. Joint Pubs
12. Other Studies

2.4.3.3 Functional Analysis

The purpose of the functional analysis is to relate the elements of the organization to the function they perform. Each functional element must then be related to the mission which is being examined to determine if that particular function is in fact required. Each individual, person or equipment item must be related to some function, however, different missions have different functional requirements. Familiarize yourself with structure of the organization, it will usually have some basis in the functions to be performed. If a new concept is being investigated the functional analysis provides a logic for developing an organizational structure based on the required functions and their relation to the required missions of the organization. The functional analysis provides the basis for the remaining steps of the unit analysis through the understanding of the functional capabilities of the organization and the requirement of the various missions for particular functions.

2.4.3.4 Select Significant Personnel Skills

The requirements for efficient computer use and cost reductions generally require an effort to be made to reduce the size of the data base. One means of accomplishing this is to combine similar personnel into one skill line entry. Actually the combination of like skills is logical for the analysis anyway. The considerations for separate listings should be different transfer capability, different substitutes available, or different vulnerabilities. If personnel cannot be differentiated by these criteria then separation in the AMORE analysis has no significance (see par 2.4.3.5 below). One should also consider the requirement for each particular skill in terms of the analysis which is being made. If there is no requirement for a particular skill to include the possible transfer into a required skill, then the skill would not be significant to the analysis and can be eliminated from consideration.

2.4.3.5 Develop Skill Substitution Matrix

The balancing of resources against mission requirements is a constant process for a military commander, in peacetime as well as combat. He must continually consider the assets available and the mission(s) requirements and reallocate the available resources to meet those demands. The potential for reallocation, the capability of one skill to perform another function, is represented in the AMORE process by the transfer, or substitution matrix. This matrix has a row and a column for every significant skill represented in the analysis (see para 2.4.3.4). Each row-column intersection is given a value which represents the time required for a person with the primary skill represented by the row to be able to function in the skill represented by the column. For example, the intersection of a row and column with equal numbers, i.e., that represent the same skill, would be expected to have a zero value to represent the time for a person of that skill to perform his own function. (NOTE: The model does not require a zero value for these elements. It does, however, assume that each survivor is functional in the primary skill immediately after the degradation is applied, the output capability at 0.00 time (see para 2.4.6.1)). All subsequent capability output will reflect any time required for those to be functional.

The time required for transfer to a different skill is derived from a combination of sources; empirical data, experience of various personnel, reference material such as AR611-201 and other data sources for skill requirements and capabilities. The analysts must be careful to insure that capabilities are not misrepresented or that significant elements of the analysis are not obscured by the combinations made in step 4, para 2.4.3.4. As noted there, different transfer capability and/or different substitute availability generally require distinction between skills. Note that the AMORE assumption in this regard is that any fill of a skill is at a basic proficiency level. This is not a requirement of the methodology and if data is available the analyst may represent any degree of proficiency, but must maintain consistency throughout the analysis.

The following considerations are useful in this process:

1. Skills within the same enlisted MOSC: Generally personnel within the same MOSC with skill level 10 and 20 can be combined and considered equal in basic proficiency. Skill levels 30 and up can generally be combined but duties within certain positions may be sufficiently different to require distinction in some skills and/or in some units.

2. Skills with different MOSC within the same career field: This area requires a close examination of the basic skill requirements across the various MOS progression ladders. AR 611-201 provides a "map" of the MOS. Within the CMF many skill level 10 personnel have a common background and can be considered equal at that level or at least transferable with a small time cost. Grade transfers across these MOS progression ladders must be examined closely.

3. Basic Combat Skills: Skills which are basic training items can be assumed equal across all MOSC at the 10 level. Skills within a team which normally work and train together are usually capable of transfer at the basic 10 level. A careful examination of skill requirements is required before grade shifts in this situation are allowed.

4. Basic Support Skills (cook, light vehicle driver, mechanic's helper, general supplyman, etc.): At the lower levels most personnel can accomplish these functions. Again, grade shifts require careful analysis as do certain skills. For instance, light vehicle drivers should not generally be combined with heavy vehicle drivers, although transfers may be possible.

5. Officers: Officers are generally managers and can assume other officer positions within some short time span required for situation

update. There are, however, more and more specialists which may not be easily replaced even though they could be used to replace other more generalized skills (See AR611-101).

6. Warrant Officers: Warrant Officers are by definition specialists and can assume each other's function only in very closely related positions (see AR 611-112). Generally they can assume a platoon leader position in their own chain of command and in some cases possibly the company commander's position, but their transfer potential is generally very limited.

The analyst should attempt to consider all possible transfers. For each row-column cell the first question is: Can the row skill substitute for the column skill in this particular mission/function? Given the transfer is possible within a time window of interest to the analysis (almost any transfer is possible given sufficient training time): Would transfer be reasonably allowed in the given situation, mission, posture under investigation? If so, what, if any, time is likely to be required for the transferee to attain an acceptable level of operational capability.

The time represented in the transfer matrix is generally an orientation time and not OJT time. The situation generally represented in an AMORE analysis is not appropriate for consideration of OJT. This does not, however, preclude the use of OJT times if the other elements of the analysis are consistent. It may also be appropriate to include travel time in the transfer time of some elements. This should be done when there is a clear distinction between locations and travel is a significant part of the transfer.

In addition to transfer time, the AMORE process considers the time required by the commander to assess the situation, re-establish control, and issue orders for the reorganization. This time is generally considered to be a function of the damage level sustained by the organization and is therefore input along with the probability of degradation (PD). The model uses this time as an increase in the transfer time for the row skill according to input. This time is added to every element of the row except the diagonal. The assumption being that each person will perform his own job without waiting for orders. This also allows the analyst to discriminate between a zero transfer time for a skill to perform its own function and a zero time to do some other function. Even for an analysis where decision delay time is not appropriate, some minimal value (such as 1) should be used to force a preference for one's own job over another with a zero transfer time.

Sensitivity analyses based on the transfer matrix can be useful for many investigations. Changes in transfer time and/or transfer capability can be used to analyze the benefits of cross-training. The effect of policy decisions may be demonstrated by examining the capability when certain transfers are allowed and when they are not allowed. Priority of reassignments may be enforced by making each lower priority slightly more costly in terms of transfer time. The analyst must relate the inputs and the outputs of the model to the questions and issues being addressed by the analysis. For example, increased level of cross-training to decrease the transfer time or increase the possible substitutes for a skill will have little effect if few substitutes are ever required.

2.4.3.6 Select Significant Equipment Items

The selection of significant equipment items is generally much more difficult than that of personnel although the same considerations are required (see para 2.4.3.4). This is caused by the proliferation of equipment items in a typical organization and greater importance of reducing the number of items considered for computer efficiency. The consideration of damage categories light and moderate, as available unit assets, causes most of the materiel arrays to be tripled in size compared to the corresponding personnel array. Again, like items should be combined where possible on the basis of same transfer capability, same substitute availability, and same vulnerability. Each item should be examined closely for its relevance to unit capability. If the item is not available does the unit suffer a significant capability loss? Does it provide an appropriate substitute for a required item?

2.4.3.7 Develop Equipment Substitution Matrix

The development of the equipment substitution matrix should generally follow the same steps as development of the personnel substitution matrix (see para 2.4.3.5). The basic time requirement is better called adaptation time than orientation time. That is, in order to perform some other function, the equipment item may require adjustments or reconfiguration. This and repositioning time are likely to be the most significant elements of materiel transfer time.

Materiel items are also considered available for use by the unit following repair of light or moderate damage. This is modeled by creating two additional transfer matrices for materiel and adding to the transfer time the appropriate repair time. Equipment which is assessed as receiving light or moderate damage then becomes the assets of these rows and are available to fill the column demands, but with the additional cost of the repair time.

2.4.3.8 Develop Mission Essential Teams

The mission capability of an organization is described in AMORE as a number of teams or increments of capability. The analyst must develop a meaningful way to express the requirements of these teams so that they truly represent increments of organizational capability.

The team requirements should reflect the essential needs to perform the mission which is being analyzed. Different missions must define different team requirements.

This process starts with the identification of the smallest (most basic) module, both people and things, of unit performance. Below this level no output, pertinent to this unit's mission, could be obtained. Examples of such modules would be an infantry fire team, an artillery piece and crew, or a tank team. These modules are usually referred to as the basic increment of capability and every organization comprises "n" such increments.

The next step is to identify the specific resources, skills and equipment, required to enable the basic module to perform its portion of the mission over the specified period. These resources are such things as command and control elements, fire control and/or fire direction elements, and support slices such as supply, maintenance and medical support. The idea here is to identify the minimal resources required to produce the increment of mission performance. No mission capability will exist if there is a shortage of these "mission essential elements." Additional increments of mission capability are constructed similarly by the addition of some minimal set of resources. These are explicitly identified until full unit capability can be realized.

To this point we have noted resources must include both personnel and equipment. In practice either of these may be used to define the basic capability increment, such as a tank or an infantry fire team, and the other is then coordinated with that base. Either way it is an iterative process to insure that the equipment has the proper personnel associated with it and the personnel have the proper equipment for mission performance.

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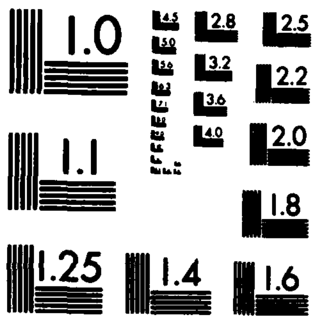

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Throughout this process the mission definition for the analysis is the primary consideration. The functions required by the mission define the resource requirements. Only those resources should be included in the mission essential team requirements. Different missions should be analyzed using a team construct for those missions. Questions as to requirements of a particular mission should be resolved or examined by sensitivity analysis of the different team build. In this way one can at least determine the effect of the requirement variation on unit capability. A large effect means that more research must be done to resolve the question. A small or no effect tells the analyst that his concern was not justified.

The AMORE model is designed to accommodate these sensitivity analyses and comparison of different mission requirements through its capability to accept multiple missions (multiple sets of team requirements). Running AMORE in this way provides a comparison of unit capability to meet the various mission requirements with the same set of surviving assets. This insures that the analysis is not confused by the stochastic process of damage application which might occur from separate runs.

2.4.4 Analysis of Degrading Mechanism

The analysis of the degrading mechanism results in completion of the last four input data requirements listed in paragraph 2.4.2, namely:

8. Damage and/or loss probabilities,
9. Damage repair times for materiel items,
10. Commanders decision or delay time prior to reorganization,
11. Time specification for capability assessment.

While these elements have already been partially addressed under Unit Analysis (para 2.4.3), the final selection of the degradation mechanism will complete these inputs and may cause modification of previous input decisions.

In fact, the selection of degradation means cannot, in general, be accomplished in isolation from those steps followed in unit analysis reviewed in the previous section 2.4.3. Therefore, in developing the suggested steps to be followed, it will be assumed that the user coordinates these processes with the unit analysis steps. As a start, the problem definition step is repeated. With the above cautions in mind, the following steps are recommended.

1. Problem Definition
2. Select Approach
3. Adjust for Environmental Degradation
4. Adjust for Individual Degradation
5. Develop Sensitivity Plan

2.4.4.1 Problem Definition

This step is suggestive that the degradation mechanism is selected in concert with unit analyses as cited above. But further considerations of the issues to be addressed may need to be made. The most accurate kind of degradation analysis is probably that resulting from JMEM*-based analysis. Given a specific unit configuration, a specific attacking weapon system and a specific scenario, JMEM-based analyses accurately predict relative losses of specified items and personnel. But the probability of finding exactly that unit configuration, weapon system and specific scenario is remote. Accordingly, this section suggests not only JMEM-based analysis but some useful alternatives.

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* Joint Munitions Effectiveness Manual

If, for example, the problem is to assess unit readiness in peacetime, JMEM-based analysis is useless.

Thus, the problem definition phase is the prelude to the selection of the approach. For the purposes of selection of degradation mechanism, the problem definition step should result in a clear statement of questions to be answered by the AMORE analysis.

2.4.4.2 Select Approach

The potential degradation mechanisms are classified as follows:

1. Point source
2. Simulation
3. Degradation spectrum
4. Unit oriented

Each will now be discussed.

2.4.4.2.1

<u>Point Source</u>. The best example of a point source degradation mechanism is that resulting from a JMEM-based analysis. It represents a single attacking weapon/munition combination, a single unit configuration, and a specified scenario. It is the best choice when we need to assess organizational vulnerability against a specific weapon/munition combination. We may, through AMORE analysis, wish to harden the unit against some specific weapon system. A judiciously selected series of these kinds of analyses can provide comprehensive insights on where the functional and individual choke points will be for the specifics described above.

Such analysis is also useful for blue-on-red type problems, i.e., when evaluating blue weapon system choices. Ideally such analysis may result in individual probabilities for each separate skill and for each materiel item to include light and moderate materiel damage with associated repair times.

Materiel damage repair times can also result from other studies, analyses, or from estimates based on proponent input.

Then the materiel is conceptual, a best guess or the closest JMEM like item is used.

The user may have to experiment with repair times in order to help discover or develop new concepts. For example, a repair specification for a new system may be derived from several AMORE trials by identifying the maximum repair time that improves capability to a required level.

Thus a combined point source analysis and parametric variation could be used where design payoffs are to be discovered.

As described earlier, the point source degradation mechanism based on JMEM analysis may be the best predictor of individual probabilities of loss. But it is wise to be explicit about the assumptions made in using such analyses results.

2.4.4.2.2

Simulation. An alternative source of relative vulnerabilities is from a simulation. Some combat simulations result in killer-victim scoreboards where relative losses of materiel (Battle model, CARMONETTE, CASTFOREM) or personnel by skill (CASTFOREM) can be inferred. In those which do not discriminate among various skills, they may at least provide relative losses of personnel-to-equipment.

Combat simulation results should be preferred when the emphasis is on assessing the unit and not a specific weapons effect. Combat simulations have the advantage of accommodating two-sided multiple weapon effects.

There are other kinds of simulations. For example, chemical effects simulations were used in the study "Logistics System Survivability in a Chemical Warfare Environment."[1] The PARACOMPT model was used to simulate the placement of chemical munitions in the vicinity of the target. The NUSSE model was used to simulate the dispersal of the agent as a toxic rain. Such simulations took into account individual/job-related vulnerabilities and degree of protection. The above two models are but examples (the Army owns those and other chemical effects simulations).

Another kind of simulation might be termed a regenerative one. If the effects of readiness degradation are being studied, one approach is to stochastically build units until various readiness criteria are met. Each resulting "unit" can be run through AMORE deterministically (two iterations of derived manning with zero probability of incapacitation) or individually.

The source for simulations can be (as with JMEM-based analysis) in-house agencies (AMSAA, BRL, CAA, TRASANA) or other analyses which use simulations.

1/ SAI, Conducted for US Army, August 1980.

2.4.4.2.3

Degradation Spectrum. The idea behind a deliberate spectrum of degradation is to gain insight regarding both the unit and a spectrum of munition attacks. The scheme is to systematically vary personnel and materiel damage levels. In its ultimate form these variations can generate results which in turn can be used in regression analyses.

In a regression analysis we attempt to fit mathematical surfaces to analytical or empirical data. As a simple example, some modern pocket calculators can develop the equation of a trend line, given sets of data. But the best fit may not be a line.*

If we think of a given set of points in space and imagine a mathematical surface close to those points, regression analysis tries to find the closest describable surface, given the points. Figure 2-28 shows a form of regression analysis which has been used for AMORE curves with success.** "Success" translates to; the "describable surface" fits the data very well. If the analyst can do (or have done for him) a successful regression analysis, he has then replaced an AMORE simulation software model with an AMORE mathematical approximation model. He can use the mathematical model with a table top calculator (programmable preferred) to draw inferences without further AMORE runs. What he cannot do is make changes in team composition or substitutability. Figures 2-29 and 2-30 show two families of curves resulting from the regression model in Figure 2-28.

* Some calculators take this into account by using linear combinations of non-linear mathematical functions.

** Also discussed in paragraph 2.4.6.1.

REGRESSION ANALYSIS

$$
\begin{aligned}
C = \; & A_0 \\
& + A_1 m \\
& + A_2 m^{(1-m)t} \\
& + A_3 mp \\
& + A_4 mp^{(1-p)t} \\
& + A_5 m^{(1-m)t} p^{(1-p)t} \\
& + A_6 pm^{(1-m)t} \\
& + A_7 p^{(1-p)t} \\
& + A_8 p
\end{aligned}
$$

C = UNIT CAPABILITY

p = FRACTIONAL LOSS OF PERSONNEL

m = FRACTIONAL LOSS OF MATERIEL

t = TIME AFTER LOSS

A_i = COEFFICIENTS DETERMINED BY REGRESSION ANALYSIS

Figure 2-28. Regression Analysis

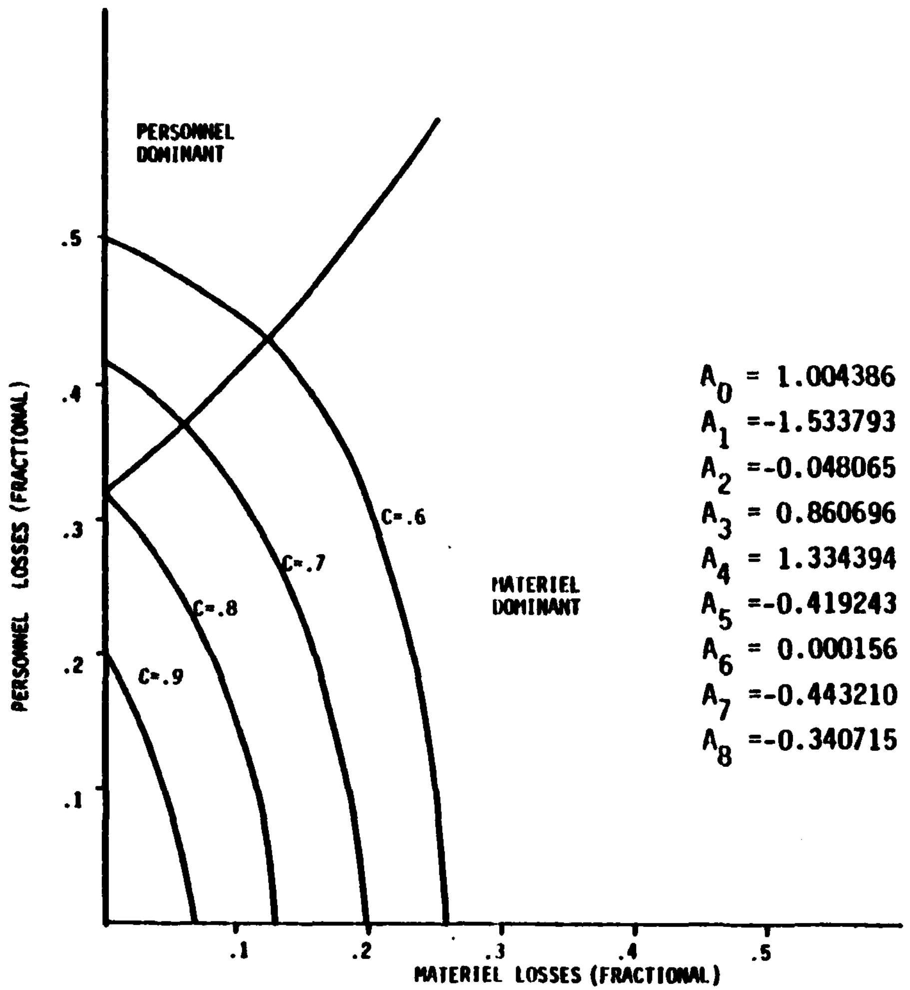


Figure 2-29. Rifle Company (Mechanized), Capability Contours for Time = 1.0 Hours

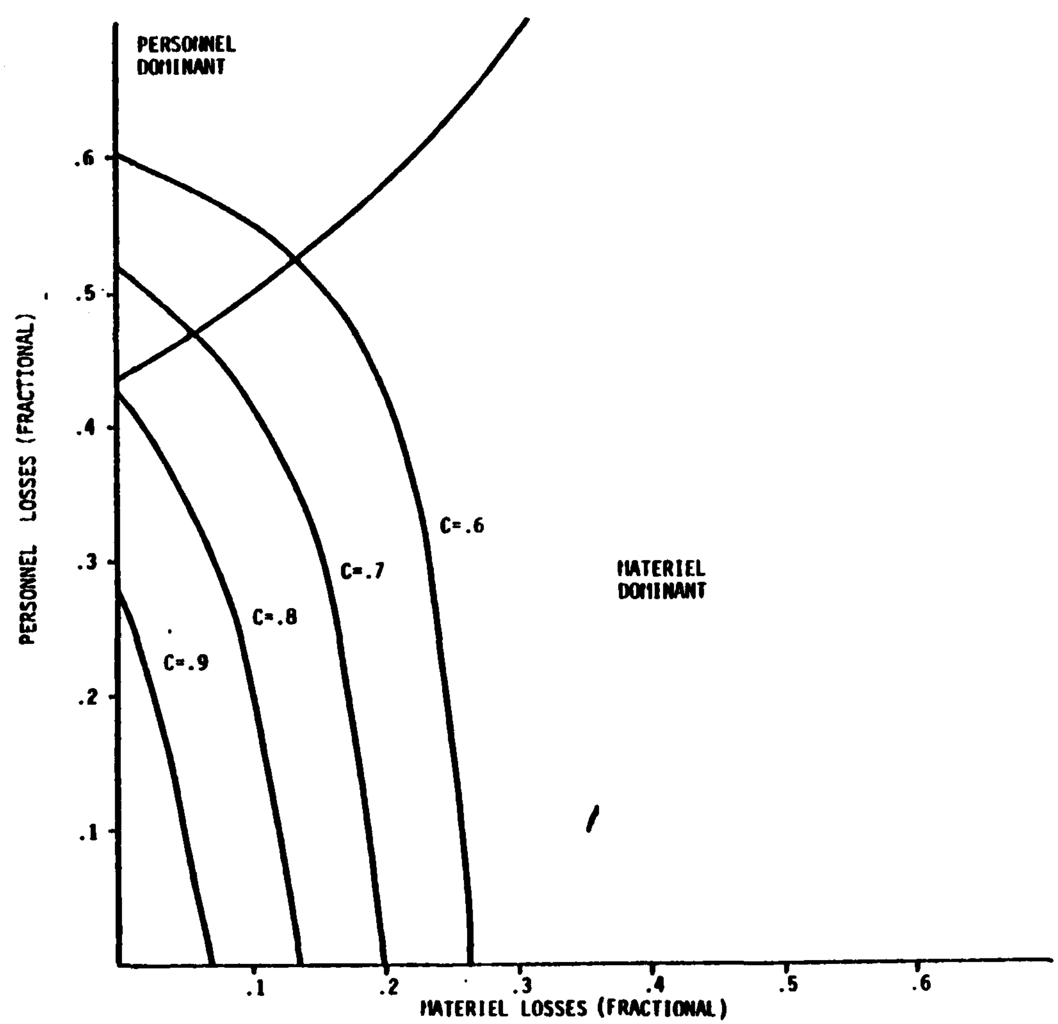


Figure 2-30. Rifle Company (Mechanized), Capability Contours for Maximum Recovered Capability

Figure 2-29 shows the values of the coefficients determined from the analysis for a Mechanized Infantry Company.* The curves were calculated from the regression equation to produce equal capability locations at one hour after an attack with applicable damage combinations. Figure 2-30 shows the same scheme for maximum recoverable capability. Comparing the two figures shows how resilient the unit is to personnel losses relative to materiel losses as recovery time increases. The spectrum of losses is much broader than from a point source (e.g., JMEM) and would likely encompass those losses encountered by units from many sources--to include peacetime readiness shortfalls, drug abuse, etc.

Other advantages of the degradation spectrum approach are that the families of curves can be easily divided into two regions.

1) Where the rate of change of capability with personnel incapacitation is higher than the rate of change of capability with materiel damage, i.e., $\frac{\partial c}{\partial p} > \frac{\partial c}{\partial m}$

2) Where the rate of change of capability with respect to materiel damage is higher than the rate of change of capability with respect to personnel incapacitation, i.e., $\frac{\partial c}{\partial m} > \frac{\partial c}{\partial p}$

In the part of the p, m plane where these conditions hold region 1 is personnel dominant and region 2 is materiel dominant. Personnel dominance means that the capability of the organization is limited by its personnel resources; likewise materiel dominance limits capability due to materiel. The curves can thus be made to build a contour map of unit vulnerabilities. In Figures 2-29 and 2-30, a line separates these two regions. Along that line the unit is both personnel and materiel limited. It would need replacements of both people and things

* The data base for this and other US organizations is contained in the Study of Sustainable Loss Rates, SAI, for US Army, Feb. 1981.

to improve capability. In a sense, the line is the unit's line of greatest vulnerability. If we can plot where we are in some scenario on these diagrams (using perhaps a combination of JMEM-based analyses), it provides insights on where the shortest paths are both to replenishment and to failure.

As an example, on Figure 2-30 if we are at the point .1/.1, a small amount of materiel damage would degrade the unit whereas a large amount of personnel damage would be required for the same lowering of capability. The shortest path to improvement at that point is restoration of equipment.

The use of a degradation spectrum approach leads to some complicated mathematical expressions, but the rewards in mathematical possibilities are manifold. The degradation spectrum approach should be considered when the degradation to be faced by a unit is unknown or uncertain. While regression analysis capability is extremely useful, it is not absolutely necessary to produce iso-capability maps. An alternative rapid approach is to produce several AMORE runs based on a systematically selected sample of points. Plot the capabilities of interest, estimate where the equal capability curves are and sketch them in.

2.4.4.2.4

Unit Oriented. The unit oriented approach to degradation is by far the simplest, easiest to implement and inherently practical from a resiliency standpoint.

The approach takes into account the fact that there are two kinds of unit reactions to degradation: (See also para 2.4.6.4)

- Population limited
- Skill or materiel limited.

For the purposes of this discussion assume we are interested in personnel only. If a unit gets attacked and has enough survivors left to fill the requirements of some number of teams (e.g., up to the 13th team) and if it can build 13 teams, it is population limited. As an example suppose a unit has 100 personnel subjected to 20 percent attrition leaving 80 personnel. Suppose further the 13th team of 17 requires 80 personnel. If I can assign or crossassign the 80 survivors to the 80 requirements, then the capability of the unit is limited only by population. I cannot possibly have more capability than 13 teams since it would require more people than those that survived.

Now consider an alternative case. There are again 80 survivors, but instead of 13 teams I can only build 11 (which required, as an example, 68 people). I must have 12 personnel surplus. Implicitly there was no way I could have reassigned personnel so as to use them all. This further implies that there is some set of skills on the 12th team (and the 13th) that I cannot fill with the remaining resources. I neither have the right skill nor a substitutable skill. In such a case we are skill limited and have much less capability for the same level of resources.

Ideally the best units are those which maximize capability for any given surviving resources. Accordingly, we have inferred a unit design goal and thereby a standard against which to measure actual units. I.e., each unit shall be population limited.

Now there is a simple way to test whether a unit is population limited and if not, why not.

1) Establish the population numbers required for capability levels of interest (i.e., add the cumulative populations required for each team level of interest).

2) Compare populations required with the unit manning population, e.g., build a table as follows:

TEAM LEVEL OF INTEREST	ESSENTIALS FOR EACH TEAM SURVIVORS REQUIRED	INITIAL STRENGTH POPULATION	SURVIVOR PERCENTAGE	ATTRITION
11	68	100	68	32%
12	74	100	74	26%
13	80	100	80	20%
14	87	100	87	13%

It is recommended that the above calculated attritions, less a small cushion be used across the board to test for resiliency at the levels shown. E.g., can we build 11 teams with 30 percent attrition, 12 teams with 24 percent, 13 teams with 18 percent and 14 teams with 11 percent?

3) Apply the adjusted attrition and look for population limiting or critical skills.

We have identified the critical points of the unit. If specific skills significantly limit achieving the goal capability level, then adjusting the organization to enable filling these skills is the most highly leveraged fix one could make to improve unit capability.

Examples of fixes are:

- o Cross train a surplus skill into the shortfall skill.
- o Harden the critical skill(s).

- Adjust the TOE to make more of the critical skill available at the expense of the surplus skill.
- Adjust the TOE to increase availability of skills that can substitute into the critical skill at the expense of the surplus skill.

Tacitly we have assumed that all skills are equally vulnerable. Procedures to test the sensitivity of the results to this assumption are discussed at paragraph 2.4.4.5 "Develop Sensitivity Plan."

2.4.4.3 Adjust for Environmental Degradation

Environmental degradation is that degradation which affects all personnel due to the same phenomenon. But each member of the unit need not be effected equally. An example of environmental degradation is that resulting from wearing chemical protective clothing. Field measurements can and have shown the best work and rest periods which various workers will be able to sustain productively. For example, given 80°F in the normal fatigue uniform with sleeves rolled up, an individual performing light duties can work for 180 minutes but must rest 20 minutes to offset the heat buildup. If his allowable work time is Wt and required rest time is Rt then his relative productivity is $\frac{Wt}{Wt + Rt} = P = \frac{180}{180 + 20} = \frac{180}{200} = .90$.

If he is performing moderate duty, his relative productivity may be .65 and if he is a heavy laborer, .30. What do these relative productivities do to the team performance?

There are two approaches to adjusting AMORE to a work to work-plus-rest environment.

The first is a direct approach and adjusts the MET (mission essential teams) to compensate for lowered relative productivity. As an example, if an individual skill's relative productivity (P) is

.5 the needs for that skill could be doubled. For each MET skill, adjust by multiplying by the reciprocal of P (rounding up to the nearest whole skills).

Now run AMORE and it is likely for any level of degradation that fewer teams can be built than for a baseline undegraded case. Accordingly, the unit will have a measurably lowered capability.

There is a second approach that gives similar results (equal capability degradation), avoids the round off problem, and can compare degraded capability with undegraded in one run. Consider the following table:

WORK STRESS	WORK (MINUTES)	REST (MINUTES)	RELATIVE PRODUCTIVITY
Light	WL	RL	PL
Moderate	WM	RM	PM
Heavy	WH	RH	PH

The P's are derived from the previous two columns; e.g.

$$PM = \frac{WM}{WM + RM}$$

There can be any number of work stress categories as long as the W's and R's are measured or can be estimated. The problem now is to translate PL, PM and PH into a relative team or unit productivity (P).

In an untrained team P is approximated or limited by the minimum value of PL, PM, or PH, i.e., P = PH. The categories other than the minimum are awaiting the end of the frequent resting of the heavy laborers or have finished their job. Is there a way of re-balancing the load to get a P > PH? The answer is to train the team for the more productive to reallocate some of their time to help the more sluggish members, i.e., we wish to find a P such that

$P \times ML$, $P \times MM$, and $P \times MH$ (where ML, MM, MH are the required mannings of the MET for light, moderate and heavy stress labor) are the effective residual capabilities for each level of stress. To do this the light and moderate categories must augment the heavy stress as follows:

$$P \times ML = P_L \times ML - M_{LM} - M_{LH}$$
$$P \times MM = P_M \times MM - M_{MH} + M_{LM}$$
$$P \times MH = P_H \times MH + M_{LH} + M_{MH}$$

where

M_{LM} = effective manning shifted from light to moderate stress
M_{LH} = effective manning shifted from light to heavy stress
M_{MH} = effective manning shifted from moderate to heavy stress

if equations (1), (2) and (3) are added:

$$P \times (ML + MH) = P_L \times ML + P_M \times MM + P_H \times MH$$

Since loss of manning shifted from one category equals that gained by another.

$$\text{or } P = \frac{P_L \times ML + P_M \times MM + P_H \times MH}{ML + MM + MH}$$

This formula is easy to interpret as the individual productivity at each stress level weighted by required manning at the level to produce an effective team productivity. P will generally be greater than P_H but the implicit assumptions are that the team is perfectly trained to use their slack time to offset the heaviest burdens.

2.4.4.4 Adjust for Individual Degradation

There is another type of degradation which occurs due to either

- o An idividual not being fully trained or practiced.
- o An individual of lower competence substituting for one of higher competence.

The first thing to realize under either of the above conditions is that the resulting mission performance may not be degraded. First we assume that the two types of degradation mean that the individual takes longer to perform at acceptable quality levels. If this assumption is not true we should disallow either the original assignment or substitution.

Now if it takes the individual longer, then it must be determined if he delays the mission cycle completion time. He may have slack in his contribution to mission performance which can absorb all or some of the protracted performance times. If the individual has little or no slack (i.e., is on the critical path for mission performance--like an artillery gunner) then the following adjustments may be made.

1) Estimate the proportional increase in mission cycle times (P) to achieve given standards.
2) Degrade the appropriate number of teams by $\frac{1}{1+P}$.

Take the first type of degradation;"an individual not being fully trained or practiced." Assume a proportion of individuals were just assigned from reserve units. They are well trained but take 10 percent longer to perform their contribution to the mission cycle. Assume further that analysis shows that this will protract acceptable mission cycle time by 5 percent and that these are assigned to half the teams. Then capability is adjusted as follows:

$$CAdj = \frac{C}{2} + \frac{C}{2} \times \frac{1}{1.05}$$

$$= .976 \times C$$

For the second case; "an individual of lower competence substituting for one of higher competence." The key is in the first step of estimating "the proportionate increase in mission cycle time" ... i.e., examine the sensitivity analysis assignment matrix. This matrix is an optional output and shows the relative frequencies of assignments and substitutions. If a substitution would add to mission cycle time but is not used, mission cycle time is not affected. Where substitutions occurred, an estimate is made as to their influence (proportionate) on mission cycle time (to include a zero proportionate change--as with the individual filling his own skill). The proportionate increases are weighted by the frequencies of all substitutions to the affected skill. (NOTE: the problem may only occur for a portion of the total replications). The weighted average proportionate increase P_W then is used to modify achieved capability, i.e.,

$$CAdj = C \times \frac{1}{1 + P_W}$$

This technique was recently applied to a field artillery battery. The gunner was considered to be on the critical path for the mission cycle. Protractions of time range from none for the gunner himself to 5 percent for the chief of section substituting to 30 percent for an ammunition handler substituting. But the preponderance of substitutions for the gunner were by the gunner himself or from skills not costing highly in mission cycle time. The net result was an expected 2.4 percent increase in mission cycle time at 30 percent incapacitation. Adjusted capability would be:

$$CAdj = C \times \frac{1}{1.024} = .977C.$$

For the particular case this was not operationally significant.

2.4.4.5 Develop Sensitivity Plan

In many instances we have assumed equal vulnerabilities among personnel skills. In other instances there may be uncertainties regarding degradation assumptions. In these kinds of instances it is usually prudent to plan for and conduct sensitivity analyses.

In particular, we would like to measure or determine the sensitivity of capability to changes assumptions regarding degradation levels. This paragraph proposes a decision tree approach which should simplify the analysis and eleminate redundant additional AMORE runs.

Consider the decision tree in Figure 2-31.

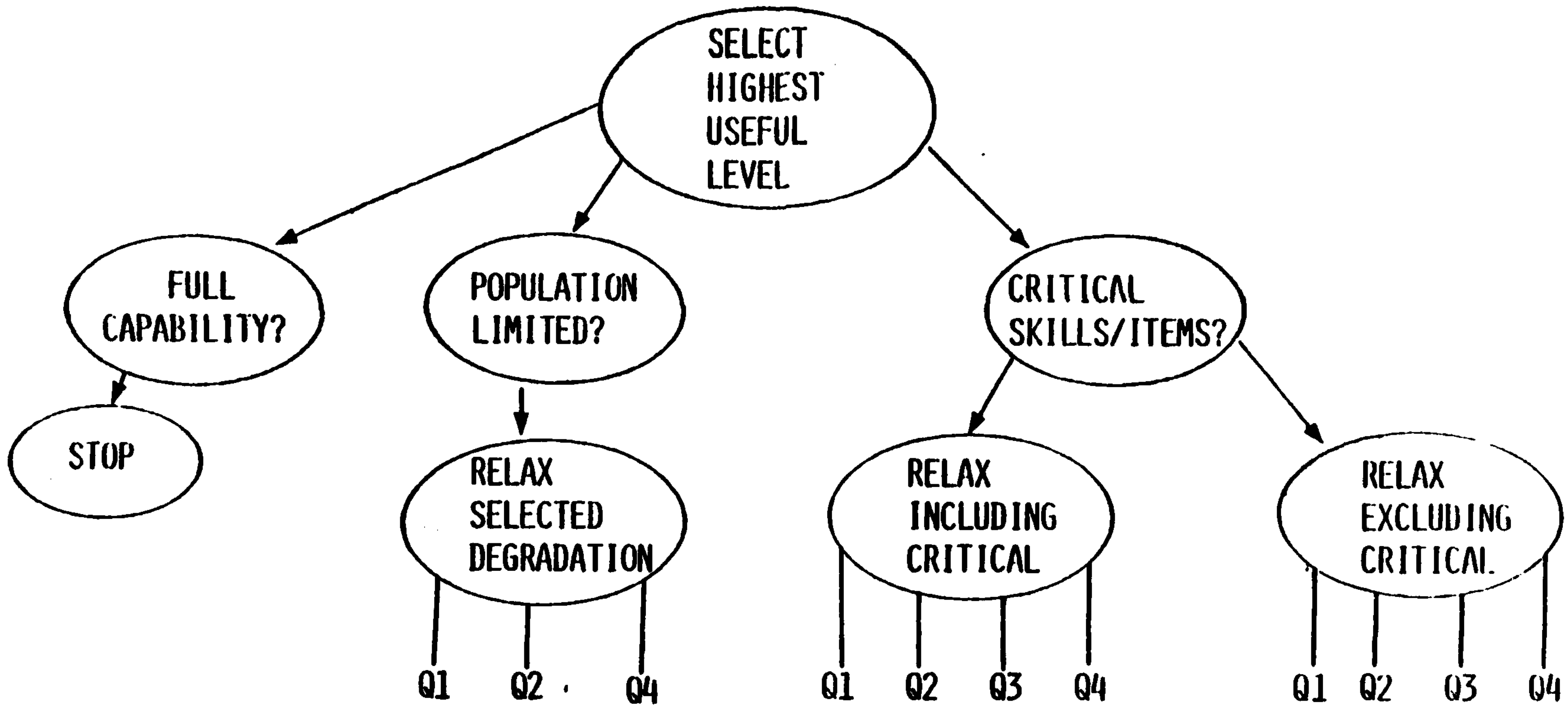
We begin by selecting the highest across the board degradation levels to include any uncertainties, i.e., "select highest useful level." If from this we realize full capability (or acceptable capability) we are finished because any lesser degradation will not worsen capability results.

If the foregoing is not the case then we are on either one of the two remaining paths. The path chosen depends on whether the highest level results in limited capability by population* or by skill/item.

In each case likely candidates are selected to relax the degradation level (likely because of uncertainty or because some skills

* Recall that in paragraph 2.4.4.2.4 we introduced the notion of population limited versus skill or item limited units. Population limited units generally used all survivors. Skill limited (or materiel item) limited units had unusable surplus survivors and less capability for want of critical skills or their substitutes.

THE SENSITIVITY OF CAPABILITY TO CHANGED ASSUMPTIONS REGARDING DEGRADATION LEVELS - SUGGESTED PATH.



Q1 DID I GET MORE CAPABILITY?

Q2 AM I POPULATION LIMITED? (IF YES, DISREGARD Q3/Q4)

Q3 ARE ORIGINAL CRITICAL STILL CRITICAL?

Q4 ARE THERE NEW CRITICAL?

IF BLUE-ON-RED PROBLEM, CAN PROBABLY(REGARD Q2, Q3, Q4 are known or expected to be less vulnerable). A new degradation level for the selected skill (item) is chosen based on estimated relative vulnerability or uncertainty. If the unit was critical skill (item) limited, then two additional runs must be made to lower attrition levels for both critical and non-critical separately.

Each path leads to a series of up to four questions to be answered concerning the results of the sensitivity runs. Note that an affirmative response to question two automatically answers questions three and four.

If the analysis does not require interest in critical people or items then we are only interested in question one which is the basic sensitivity question.

2.4.5 Output Analysis

The AMORE model outputs fall into two categories; standard output and optional output.

Standard outputs are:

1) Input data.
2) Capability as a function of time.
   a) Using transfer time input as the mean of a distribution.
   b) Using the input mean transfer times deterministically.
3) Integral of the capability over time function.

Optional outputs are:

1) Sensitivity analysis assignment matrix.
2) Sensitivity analysis needs and surplus (choke analysis)

a) Single optimal solution considered.

b) Multiple optimal solutions considered.

The model has input option flags to enable the analyst to choose the output desired. The input only flag is used to have the model read the data and provide a reformatted output of the data to assist in verification. When this flag is set, other flag settings have no effect other than to invoke warning message printing if settings are inconsistent. If the input only switch is set to zero, then model processing will occur and results data will be output as selected by other option flags.

The number of iterations or the number of stochastic applications of the input probability of degradation must be selected by the user. All desired calculations are made following each application of the degradation and results are then averaged over the iterations. The results therefore represent the average capability, etc., of the unit given many samples of surviving assets as opposed to the capability of the unit given an average set of survivors. The number of iterations used is important to the statistical significance of the results. Sufficient iterations are required to obtain convergence of the results while insuring the most efficient use of computer resources. See paragraph 2.4.6 for more detail.

If the remaining options are zeroed the standard output of a complete model run is the capability as a function of time and the integral of the capability over time, or area under the capability-time curve. This capability is calculated from the teams completed using the assets available at a particular time. The time of availability is normally picked randomly from a distribution using the input time for a transfer to become effective as the mean of that distribution. By means of an option switch the user may choose to use the input times directly without sampling.

The assignments made to complete the team build may be examined by selecting the optional output of the assignment matrix. As noted above, each application of the degradation results in a different set of surviving assets. These assets will then be allocated in a way that results in the completion of the largest possible team in the minimum time. The results of these assignments are output in the Sensitivity Analysis Assignment Matrix if that output is selected.

If the unit capability is below its maximum the obvious question is why? What does the unit require to build more teams? This information is available through the optional output, Sensitivity Analysis Needs and Surplus. This output is commonly referred to as the "choke" analysis, in that it identifies the assets which are choke points to completion of a higher unit capability. The model identifies these choke points by attempting to complete one more team increment than the maximum achievable, identified above, and determining what is missing. This attempt is made again in a way to optimize the completion of that team in the minimum possible time. The solution chosen by the model will be an optimum solution, but <u>may</u> be one of the many possible optimum solutions. The normal mode for the model is to use this first optimal solution only, the results representing averages of the first solution from a number of iterations. As noted above, any particular iteration may have any number of optimal solutions. These may be examined through use of the multiple optimal solution option switch. This option must be used in conjunction with the choke option and is very costly in computer time due to the long searches, solution comparisons, dead ends, and restarts required.

The discussions in the remainder of this section will refer to output examples presented in Section 2.3. The reader should refer to that section during study of this section. The discussions will be limited to results output.

2.4.6 Output Options

The output options noted above have been included in the AMORE model primarily to reduce computer time requirements when certain data are not desired or required. The analyst must decide which data is required as a part of the problem definition phase. He must know what questions are being asked and what measures of effectiveness (MOE) or measures of performance (MOP) may be useful in answering these questions. Some potential MOE/MOP are:

1) Capability as a function of time.
2) Potential productivity, derived from area under the capability over time curve.
3) Sustainability, the change of capability with respect to a change in loss rate (personnel or materiel).
4) Change in recovery (reconstitution) time or rate.
5) Identification of who or what is critical to additional capability.
6) Assignments made for reconstitution.

Establishing the MOE/MOP necessary to the study will assist in answering the question of: What comparisons are to be made? Is a base case needed and if so how should it be defined? Is it necessary to examine several missions? Are different levels of asset loss to be applied? Over what range? Are they scenario determined or parametric values? Many of these questions will have been addressed and possibly answered during the input development. Many of the ideas discussed here are also addressed in paragraphs 2.4.2-2.4.4. They are also important in determining what output data is required and in how it must be presented to answer or provide insights to the major study issues.

2.4.6.1 Organizational Capability

The organizational capability is output as a function of time in terms of personnel, materiel, and the composite unit or minimum of personnel and materiel. The results represent the average of all iterations. Figure 2-32 shows a typical presentation of this data. Figure 2-32 represents the data shown in Figure 2-20, page 2-50 to include a representation of the 90% confidence interval. The confidence interval shows the band (+/-) within which 90% of the values are expected. The width of this band is inversely proportional to the square root of the number of iterations or samples. Therefore, it will require approximately four times the number of iterations to reduce the confidence interval by half.

Figure 2-32 shows a great divergence of the personnel and materiel capability over time. It further shows that materiel is always the limiting or minimum factor at any time greater than 0.5 hours. At that time the materiel capability and unit capability become equal and remain so. Prior to a half hour there were some cases where personnel capability was lower than the materiel capability, this drove the average unit capability lower than either.

The results shown are based on sampling of a distribution to establish the time of availability for each transfer. An option is available, discussed above, to use the times directly as input. Time of availability for a transfer is the sum of the transfer time, commander's decision delay time (except for diagonal elements of the transfer matrix), and, when appropriate, the repair time. The time when each person or materiel item will be available for use on a team is determined using this time directly or as the mean of an exponential distribution. Figure 2-33 provides a comparison of the unit capability curve from Figure 2-32 (Sampled Times) and the unit capability results when only the mean times are used (data from Figure 2-26, page 2-63).

Note that both curves start and end (infinite time) at exactly the same value, thus demonstrating the fact that changing the transfer

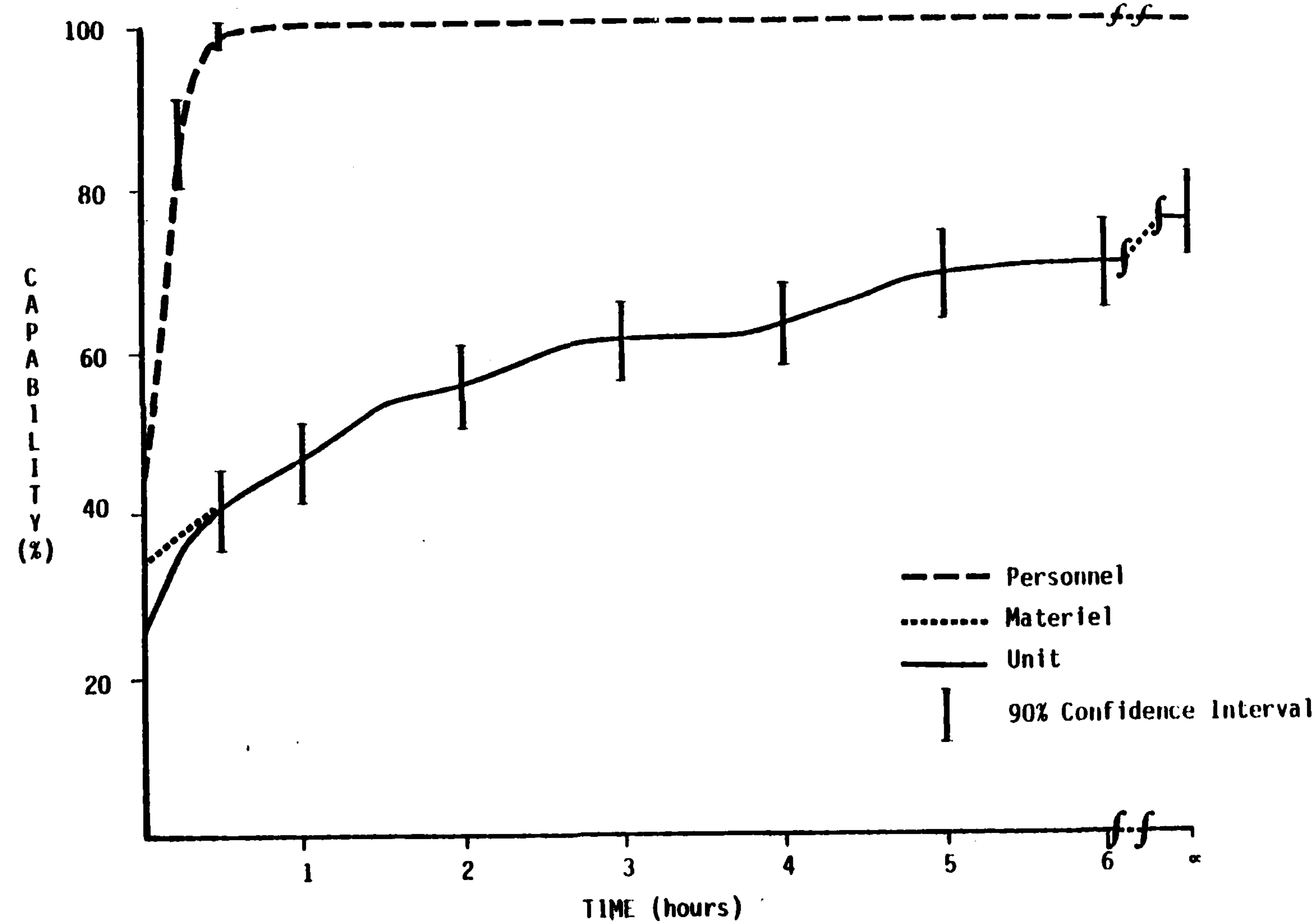


Figure 2-32. Capability as a Function of Time

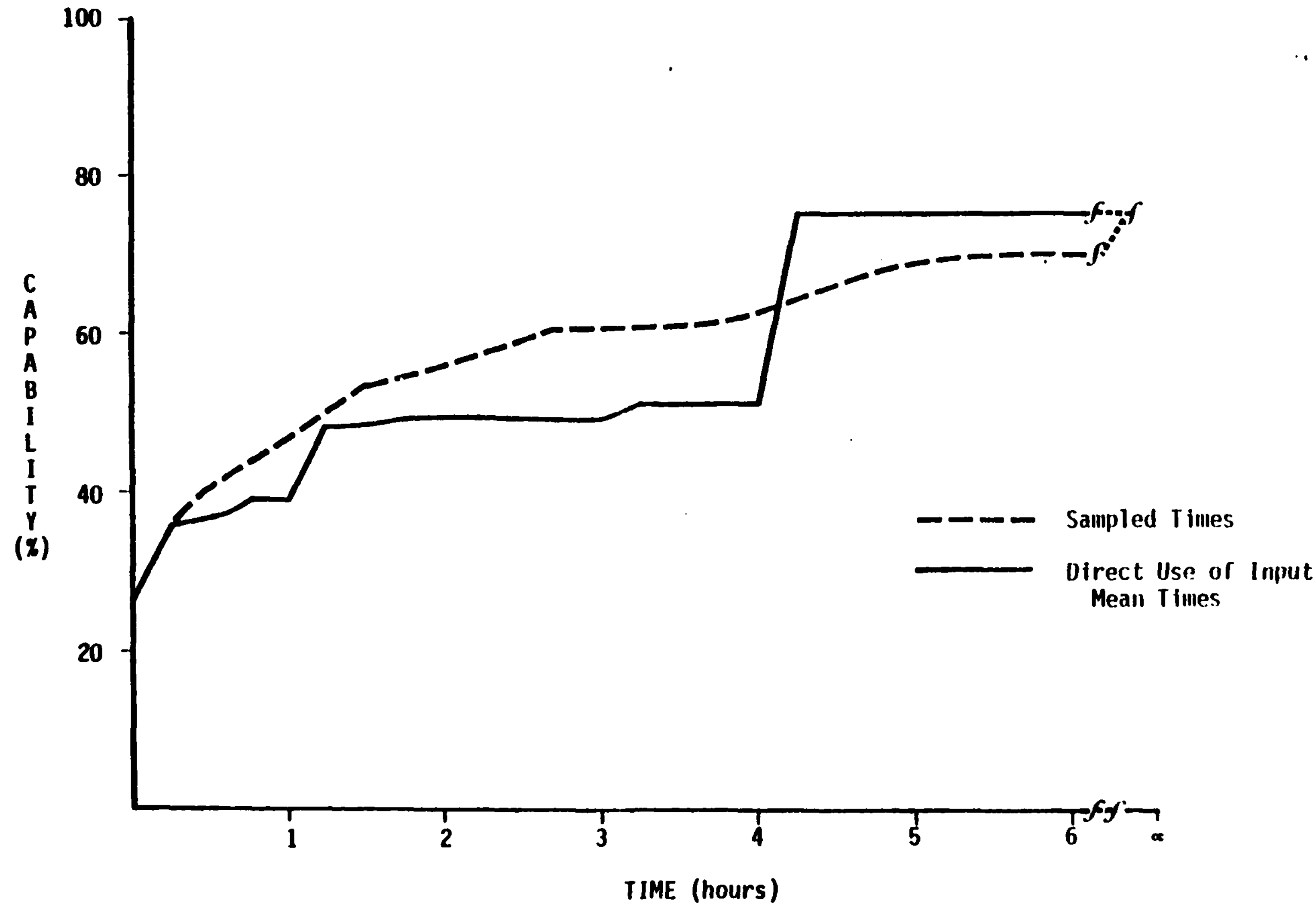


Figure 2-33. Comparison of Unit Capability, Sampled Distribution of Transfer Times Versus Direct Use of Input Transfer Times

times may change the time or rate of recovery but will not change the total capability recovered. When the distribution of times was used there were several instances when total recovery was not realized until after six hours. The infinite time capability is shown to demonstrate this gain in capability after, or later than, the last specified time. Although the figure does not show it, the data shows that when the mean times were used maximum recovery was reached at 4.75 hours. As noted, when the times were sampled some items were not available until after the six hour time frame established for the study. These items were, however, expected (mean time) to be available prior to six hours, as shown by the mean time case the longest mean time was less than 4.75 hours. It also shows that almost always returns were complete prior to 4.25 hours. Any item which has a total expected time exceeding the last specified time, in this case six hours, would be assumed not available for reconstitution, including infinite time. This assumption always applies even though sampling might result in the occasional availability of the item within the designated time frame.*

This fact of model behavior has been used to demonstrate the effect of changing policy for reallocation of assets. The time or rate of recovery was not an appropriate MOE so the transfer times were redefined as indices of assignment policy. The maximum time horizon was then set so that different policy indices were included (or excluded) on different runs. This allowed one simple input change to reflect what became a totally different transfer matrix with no changes actually made to the transfer matrix.

A presentation of unit capability as a function of personnel and materiel losses is shown in Figure 2-34. This presentation results from a mathematical model of the unit response to losses based on

* The software behavior "imitates" a cammander's elimination of options based on planning times beyond his planning horizon.

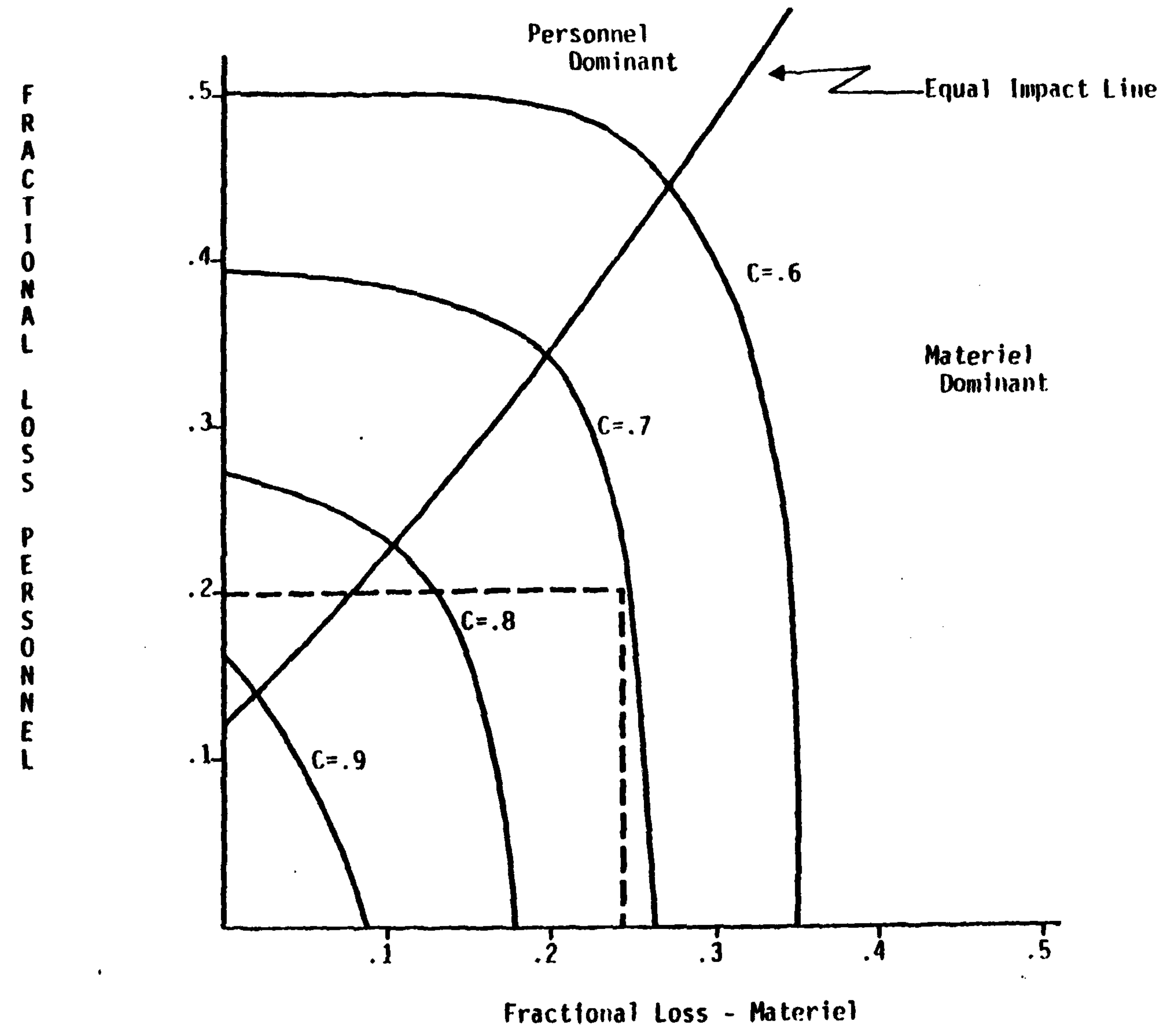


Figure 2-34. Example Capability Contour Chart

regression analysis using the results from many AMORE runs. Specific damage combinations and levels of losses are scenario dependent and subject to wide interpretation and variation. Combat intensity or the levels of losses a commander will accept or allow before breaking contact are difficult to predict. For these reasons a generalized parametric approach to unit analysis is sometimes appropriate and may provide insights to a wide variety of specific scenario cases. Charts such as the one at Figure 2-34 or the mathematical model used to complete the chart provide this capability (see also para 2.4.4.2.3).

A mathematical model developed by SAI is shown below. This model has been found to provide good regression results for the many units it has been applied to by SAI.

$$C = Ao + A_1m + A_2m^{(1-m)t} + A_3mp + A_4mp^{(1-p)t} + A_5m^{(1-m)t}\ p^{(1-p)t} + A_6pm^{(1-m)t} + A_7p^{(1-p)t} + A_8p$$

Where C = Unit Capability
t = Time After Loss
p = Fractional Loss of Personnel Assets
m = Fractional Loss of Materiel Assets
Ai = Coefficients Determined by Regression Analysis

The coefficients (Ai) of this Unit Capability/Time Model are unit dependent. The unit must be defined by mission, mission essential team structure, and transferability of personnel and equipment items. Changes to any of these items would require re-validation of the unit model and would be likely to produce a different set of coefficients.

This model makes it possible to plot the unit capability curve as in Figure 2-32 for any particular combination of personnel and materiel losses. A much greater utility is demonstrated by Figure 2-34 where capability contours as a function of personnel and material losses are plotted for some particular time after loss.

The capability contour chart is divided into personnel and materiel dominant regions by the equal impact line. This line is more accurately a zone which, for convenience, has been represented by a line. The equal impact line connects points on each capability contour where the capability is changed equally by a change of personnel <u>or</u> materiel loss. The regions identify the factor which is dominant to changes in unit capability. For example the point p =.2, m = .24 (Figure 2-34) is located in the materiel dominant region. Changes of the net materiel losses, either by increasing damage or by replacement of losses, will have a greater impact on capability than changes in the personnel loss. At this particular point a change in m of ± 0.1 results in a change of capability of approximately ± 0.1. It can be seen that a large increase in personnel loss (0.28) would be required to lower the capability from 0.7 to 0.6. A decrease in the personnel loss to zero would have little effect on capability.

The chart graphically portrays the response of a unit to losses. The units inherent sustainability and sensitivities are apparent and may point out areas requiring further study. For example, if the unit is shown to be extremely sensitive to losses, what is the cause? What are the possible improvements? (i.e., hardening, cross-training, redundancy, etc.) What are the threats to this unit? Given specific threats or scenario defined losses, would personnel or materiel replacements have a greater impact on capability? Within the force context, are more of these unit types required to insure sufficient capability, given a defined scenario?

2.4.6.2 Potential Unit Productivity

For some analyses a possibly more meaningful measure of the effect of unit degradation is provided by the integral of capability over time. This area under the capability curve provides a measure of the accumulated effective unit hours over some time frame. The effective unit hours available to a unit define the maximum output potential of the unit in time.* The quantification of this relation is generally straight-forward for units which produce some easily measurable output. Other units may present varying degrees of difficulty in establishing the relation between effective time and productivity. This measure is particularly important in an operational situation where a certain minimal amount of output is required from a unit. The unit may be able to attain some specified capability level but lose a significant amount of productivity in the process. If the output of the unit is critical to an ongoing operation, the ultimate capability attained by the unit may be less important than the effective unit hours available.

Figure 2-35 shows the capability/time curves for a Tank Company considering two loss cases. Both cases have 30 percent personnel loss; differences are in materiel loss. Case 1 reflects a 30 percent materiel loss. Case 2 also has a 30 percent materiel loss with an additional 10 percent crew repairable damage (20 minutes mean time) and 10 percent unit repairable damage (240 minute mean time). In both cases the unit is able to attain 70 percent capability.

Figure 2-36 shows the effective unit hours for these two cases compared to a reference line representing a unit at 60 percent capability over the entire time. Case 1: the unit requires 5 hours to have the same output potential as a 60 percent unit even though the unit capability is up to 70 percent in 2 1/2 hours. Case 2: the unit output potential is well below that of a 60 percent capable unit for an extended period of time. Figure 2-35 shows the unit in Case 2

* This, in turn, can be converted to potential product (such as ammunition throughput short tons).

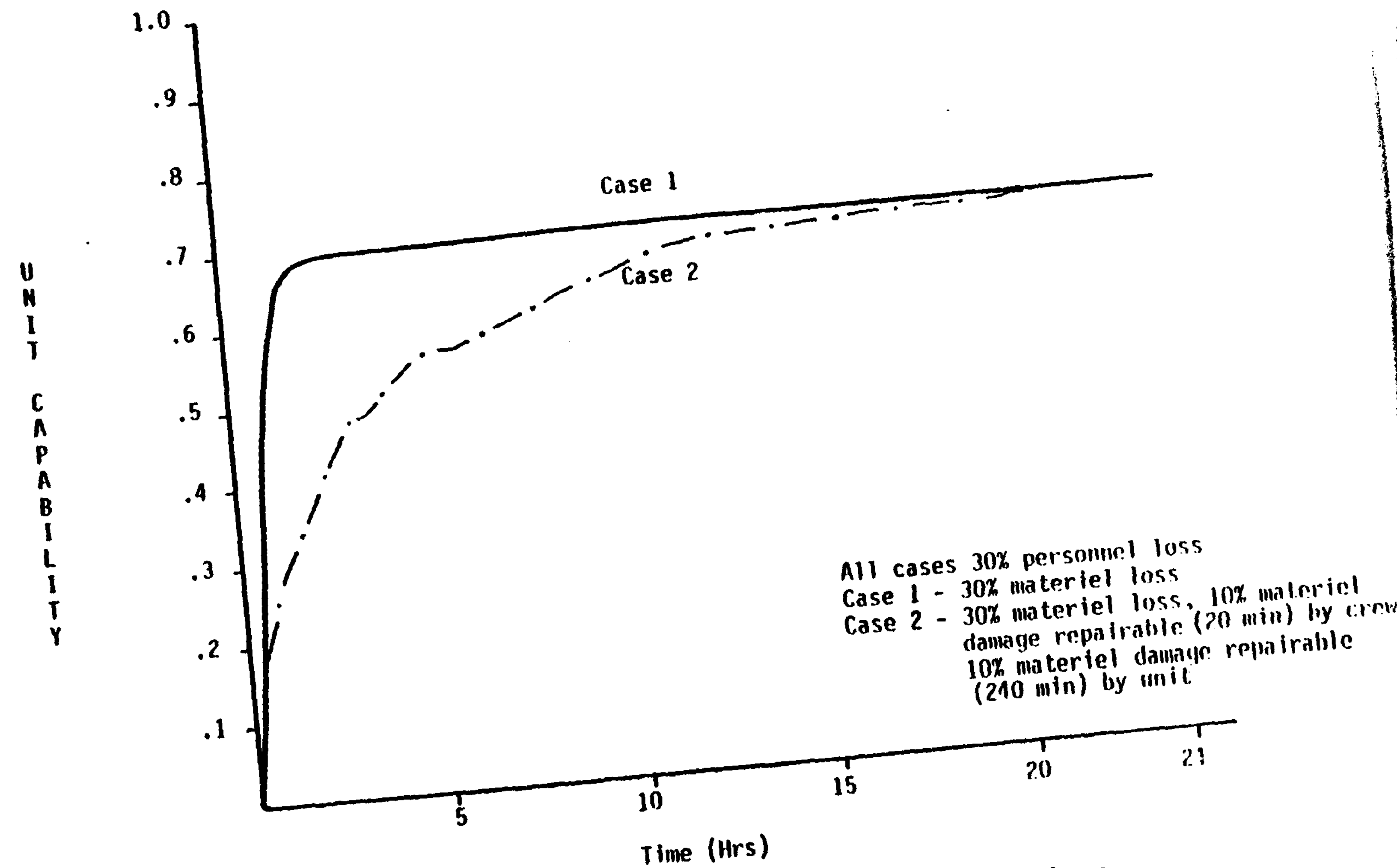


Figure 2-35. Tank Company Capability Recovery, Sample Cases

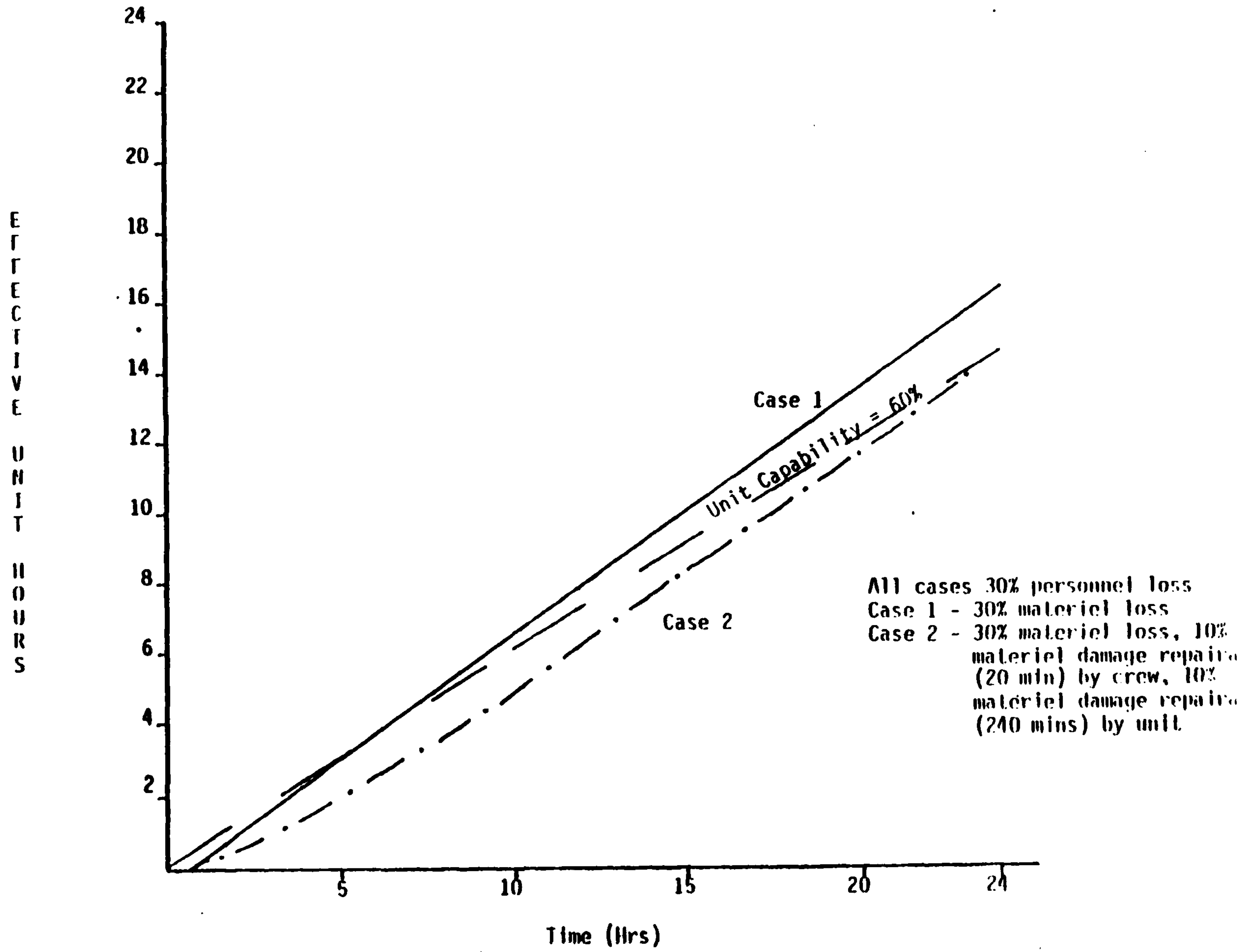


Figure 2-36. Tank Company Effective Unit Hours, Sample Cases

is above 60 percent capability after 8 hours but 24 hours is required to match the effective unit hours.

Figure 2-37 shows the effective unit hours, equated to ammunition handling capability, for an Ordnance Ammunition Company after 30 percent personnel loss with: Case 1, 10 percent materiel loss and Case 2, 10 percent crew repairable damage (20 minutes mean time), 10 percent unit repairable damage (240 minute mean time), and 10 percent materiel loss. In both cases the unit recovers to approximately 70 percent capability with Case 2 requiring a significantly longer time. A comparison is also provided for a unit at 60 percent capability for the entire period. In Case 1, although the unit attains 70 percent capability in 4 hours, it requires 7 hours to provide the ammunition handling capability of the 60 percent unit. In Case 2 the unit requires approximately 22 hours to match the productivity of a 60 percent unit even though unit capability is above 60 percent at 6 hours.

The potential productivity provides a measure of effectiveness for units which has utility for use in force effectiveness evaluations. The user must define the time of interest and the requirement standard for the unit. The effect of a specific loss to the unit can then be related to its effect on the force. The AMORE model provides this data as a part of the standard results output. Data for both unit hours and team hours (unit hours x number of unit teams) is provided so that the measure most relevant to output production may be used by the analyst. A sample of this output is given in Figure 2-21, Page 2-51.

2.4.6.3 Assignment Matrix

Each iteration of asset degradation results in a different set of survivors. These survivors are likely to result in a different

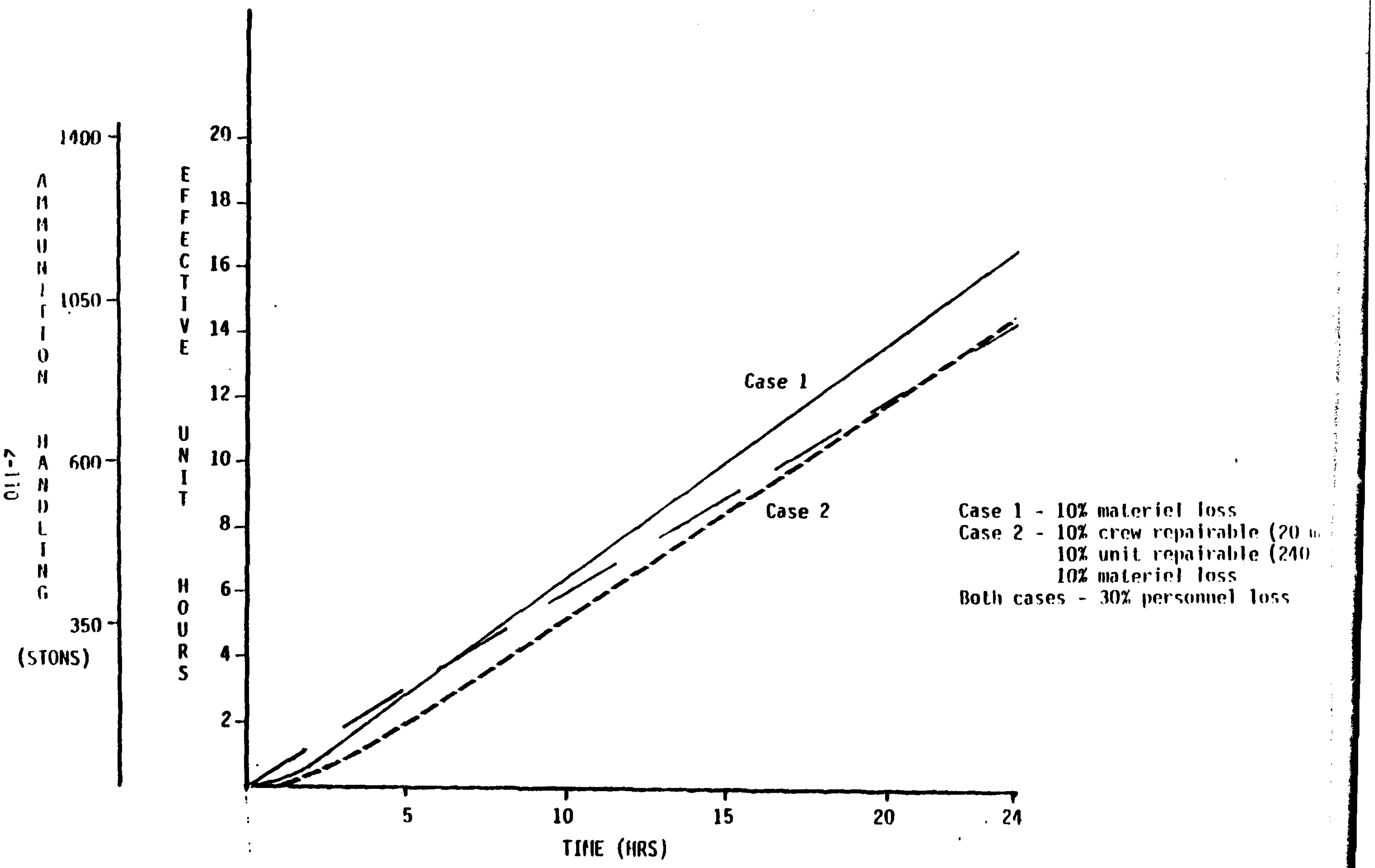


Figure 2-37. Ordnance Ammunition Company Effective Unit Hours, Sample Cases

team reconstitution capability on different iterations. The assignments made for reconstitution on each iteration are compiled by the team level accomplished. The assignment matrix output is the average assignments made to build team "X" for all those iterations where team "X" was the maximum reconstituted level. A sample of the assignment matrix output is shown at Figure 2-25, pages 2-61 and 62.

The assignment matrix is provided for the investigation of how reallocations were made to reconstitute unit capability. One of the first uses is to see what high time cost reallocations were made. Any significant number of transfers required to reconstitute the unit, point out possibilities for improvement of recovery time through additional cross-training. Those required transfers with a high time cost, and the possibility of significant reduction, offer the opportunity for the most significant gains. As noted previously, changing transfer times will not improve the ultimate capability achievement but may have a significant impact on rate of recovery and therefore on the effective unit hours. However, if the assignment matrix shows few or none of a particular transfer was used then changing or even eliminating that transfer capability would have little, if any, effect on unit recovery.

The assignment matrix also shows what was excess to the designated team requirements (SURPLUS column) and the total survivors in each skill or materiel item. Materiel items are further divided by the categories of undamaged, light damage, and moderate damage. Assignments required from the damaged items show where it may be important to have maintenance personnel, parts, and equipment to aid in unit recovery. By the same token the surplus or excess items in the damage categories show where a repair capability would have no, or little benefit to unit recovery.

2.4.6.4 Choke Analysis

For those occasions (iterations) when the unit is unable to reconstitute full capability the obvious question is: Why? The choke analysis output provides this information. The data is compiled by team level in the same manner as the assignment matrix data. For each iteration that team "X" is able to be completed, the model will attempt to reconstitute team "X+1". The personnel or materiel items which are needed but not available to complete team "X+1" are referred to as the "choke points." The data output by the model is again the average for all those iterations where the team level "X+1" was next above the maximum recovered capability. The iterations correspond directly to those shown in the assignment matrix for team "X", as do the total assets available. A sample of the choke data output is shown at Figure 2-22, page 2-58.

The data shown in the choke analysis output are the things needed (NEEDS) to complete the designated team and those things excess (SURPLUS) to the requirements of that team. Each value is the average per iteration for the numbers of iterations shown. The standard deviation for each value is also given. The choke data identifies those personnel and materiel items critical to additional capability in the unit. The surplus items show where possible transfer capability additions could be used to increase unit recovered capability. Increasing the transfer capability to skills or items not needed or not critical for additional capability is not likely to provide a significant increase in capability. There is a possibility of creating other ways to satisfy the needs and thus gaining some capability, but the most significant effect on unit capability recovery will be provided by the creation of new sources of the critical personnel or materiel items, whether by cross-training, redundancy, or replacement. Further, it may do the unit little good to provide personnel replacements if its capability is materiel dominated (or vice versa) in the scenario of interest (see para 2.4.6.1.

In some instances you may find a unit is population limited as opposed to skill limited. That is, the team level reconstituted is always the maximum level that could possibly be completed with the total number of surviving assets. This finding is a result of the choke analysis. If the choke surplus is all zeros then all assets on-hand were used and the choke need reflects a shortage of total assets and not just a specific skill. In this case, additional transfer possibilities will not enhance the unit capability. The only way to increase the unit capability is to increase the total assets available either through replacements or increasing their survivability (see also paragraph 2.4.4.2.4).

CHAPTER 3

ANALYST - PROGRAMMER INTERFACE

3.1 INTRODUCTION

In order to properly input data for any computer program, the data must conform to particular computer language specifications and must be entered in a specific order. For the AMORE computer program, the input data must conform to formats and specifications of the FORTRAN computer language. This chapter provides the bridge between developing the input data (Chapter 2) and entering it into a computer.

The following section contains specific information needed to prepare the input data for model entry. The section is subdivided by data card type (logical record). The card type numbers indicate the sequencing order of the input data. Each subdivision contains a brief discussion of the items on the card, a summary of the card input format, and a sample card image. Within each card type input format summary, the data items contained therein are progressively numbered for column usage from left to right. For each item's column usage, a specific FORTRAN format, variable name and brief description corresponding to that discussed earlier are displayed. The values used in the sample card images come from the mechanized infantry company example of Chapter 2. Note that a "Δ" denotes a blank space.

Each input data card has been assigned a type designation (1-14). If multiple cards are required, within a card type, sequence number 1 through the number of cards required is assigned. If a single card is required, sequence number 1 is assigned. These designators are punched in card columns 76-80, with the card type in columns 76-77 and the sequence number in columns 78-80.

Whether batch processing (card input) or time sharing via remote terminal are used, the same formatting for input must be used. Therefore, the formatting instructions apply to both batch and remote terminal processing and must be adhered to.

3.2 CARD INPUT FORMATS AND IMAGES

3.2.1 Card Type 1

This card image is used to initialize six processing parameters. The first is the number of iterations to be executed. For the example problem, fifty iterations were considered sufficient to provide statistically correct results (ITRATE = 50). The second controls whether or not an analysis of "choke" data is to be provided as output. In accordance with the problem statement, "choke" data is required (SCHOKE = 1). The third parameter governs the optional printing of the assignment table(s). This is required as part of the problem solution (ASSIGN = 1). The fourth parameter controls the number of solutions that are to be derived. For this exercise assume no alternate solutions are desired for choke analysis (MULTF = 0). The fifth parameter controls whether fixed transfer times or statistically determined transfer times would be used for calculation of capability. For this solution a random distribution of the transfer times is desired (IMEANT = 0). The last (sixth parameter) permits the user to have the program print input data without further processing in order to verify data correctness without wasting valuable computer run time. The use of good data processing techniques such as this is highly desired and is used in this example (IONLY = 1). Following verification of the input, the value of IONLY can then be changed to zero for program execution.

Input formats and a sample card image appear in Figure 3-1. These inputs are discussed in Sections 2.2.4.2 through 2.2.4.7.

CARD TYPE	FLAGS (RUN CONTROL AND PROCESSING PARAMETERS (ONE CARD)				
ITEM	CARD COLUMN	FORTRAN FORMAT	FORTRAN VARIABLE	DESCRIPTION	SAMPLE VALUE
				NOTE: Standard output for any run is the "capability over time" tables; all other output is optional.	
1	1-5	I5	ITRATE	ITERATION FLAG No. of iterations of the model estimated to produce statistically meaningful results. This value must be greater than or equal to two for proper program execution.	50
2	6-10	I5	SCHOKE	CHOKE FLAG If SCHOKE=1, perform choke analysis; print "needs & surplus" tables. If MULTF > 0 find alternate optimal solutions if they exist. If SCHOKE=0, bypass choke analysis.	1
3	11-15	I5	ASSIGN	ASSIGNMENT MATRIX FLAG If ASSIGN=1, print the assignment table for the optimal allocation of available resources to make teams. If ASSIGN=0, bypass these procedures.	1
4	16-20	I5	MULTF	MULTIPLE OPTIMAL SOLUTION (MOS FLAG) MOS's are alternate allocations having the same time cost (transportation algorithm); applies only to the choke analysis. If MULTF=1, find as many solutions as possible & average. If MULTF > 1, search for MULTF solutions & average. If MULTF=0, find only one solution.	0
5	21-25	I5	IMEANT	MEAN TIMES ONLY FLAG If IMEANT=0, calculate capability over time using randomized mean transfer times (standard run); if IMEANT=1, use input mean times.	0
6	26-30	I5	IONLY	INPUT ONLY FLAG If IONLY=1, list inputs without processing them. If IONLY=0, processing occurs & input data as well as selected output are printed.	1
	31-75	45X	---	Blank	Blank
7	76-77	I2	ITYPE	CARD TYPE: ITYPE = 1, value of this card type (must be specified).	
8	76-80	I3	ISEQ	CARD SEQUENCE NUMBER FOR THIS CARD TYPE: ISEQ = 1, the card sequence number for this card type (must be specified).	

/ΔΔΔ50ΔΔΔΔ1ΔΔΔΔ1ΔΔΔΔ0ΔΔΔΔ0ΔΔΔΔ1...(45Δ)...1ΔΔ1

CARD TYPE 1 IMAGE

Figure 3-1. Card Type 1 Input Format and Sample Card Image

3.2.2 Card Type 2

The purpose of this card is to input the number of time slices at which capability after degradation is to be evaluated. In this case, measurements are to be taken at quarter hour intervals for six hours or (6 x 4 = 24) time slices. The capability at zero, minimum, and infinite times are automatically calculated and therefore are not included in the summation of time slices.

Input formats and a sample card image appear in Figure 3-2.

CARD TYPE #2	NUMBER OF TIME SLICES THIS RUN (ONE CARD)				
ITEM	CARD COLUMN	FORTRAN FORMAT	FORTRAN VARIABLE	DESCRIPTION	SAMPLE VALUE
1	1 - 5	I5	NTIMES	No. of times unit capability will be assessed after initial degradation.	24
	6 - 75	70X	---	Blank	Blank
2	76 - 77	I2	ITYPE	CARD TYPE: ITYPE = 2, value of this card type (must be specified).	2
3	78 - 80	I3	ISEQ	CARD SEQUENCE NUMBER FOR THIS CARD TYPE: ISEQ = 1, card sequence number (must be specified).	1

/ΔΔΔ24...(70Δ)...Δ2ΔΔ/1|

CARD TYPE 2 IMAGE

Figure 3-2. Card Type 2 Input Format and Sample Card Image

3.2.3 Card Type 3

This card inputs the time slices at which capability measurements are to be taken following degradation. For the twenty-four quarter hour slices, measurements are to be taken at 0.25, 0.50, 0.75, ..., 5.75 and 6.00 hours following degradation. The following format is used to input these time slices. Note that only seven times per card can be entered. Therefore four cards are required (3 x 7 = 21 values on cards 1 - 3, and three values on the fourth card.)

Input formats and a sample card image appear in Figure 3-3. This input is discussed in Section 2.2.4.1.

CARD TYPE = 3	SPECIFICATION OF TIME SLICES (NTIMES VALUES, 7 VALUES/CARD) Hours elapsed from time zero, at which time, capability is to be measured				
ITEM	CARD COLUMN	FORTRAN FORMAT	FORTRAN VARIABLE	DESCRIPTION	SAMPLE VALUE
				NOTE: All values must include a decimal point, e.g., 1.0 hrs or .10 hrs. The TIMES values must be in ascending order.	
1	1-10	F10.0	TIMES(1)	First time of interest.	0.25
2	11-20	F10.0	TIMES (2)	Second time of interest.	0.50
. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
7	61-70	F10.0	TIMES (3)	Seventh time of interest	1.75
	71-75			Blank	Blank
8	76-77	I2	ITYPE	CARD TYPE = 3	3
9	78-80	I3	ISEQ	CARD SEQUENCE NUMBER: Note increment card sequence by 1.	1

Card 4 ΔΔΔΔΔ5.50.......................3Δ4

Card 3 ΔΔΔΔΔΔ3.75...........ΔΔ5.25ΔΔΔΔΔΔ3ΔΔ3

Card 2 ΔΔΔΔΔΔ2.00............ΔΔ3.50ΔΔΔΔΔΔ3ΔΔ2

Card 1 ΔΔΔΔΔΔ0.25ΔΔΔΔΔΔ0.50....ΔΔ1.75ΔΔΔΔΔΔ3ΔΔ1

CARD TYPE 3 IMAGES

Figure 3-3. Card Type 3 Input Format and Sample Card Image

3.2.4 Card Type 4

This card type inputs the number of personnel skill groups found in the organization. The specific skill groups will be entered using Type 5 cards. There are thirty-five skill groups (thirty-five cards) to be read in following this card.

Input formats and a sample card image appear in Figure 3-4.

CARD TYPE #4	NUMBER OF PERSONNEL SKILL GROUPS (ONE CARD)				
ITEM	CARD COLUMN	FORTRAN FORMAT	FORTRAN VARIABLE	DESCRIPTION	SAMPLE VALUE
1	1 - 5	I5	NTASKS(1)	Number of personnel skill groups to be analyzed.	35
	6 - 75	70X	—	Blank	Blank
2	76 - 77	I2	ITYPE	CARD TYPE = 4	4
3	78 - 79	I3	ISEQ	CARD SEQUENCE NUMBER: Single Card = 1	1

/ΔΔΔ35.............Δ4ΔΔ1|

CARD TYPE 4 IMAGE

Figure 3-4. Card Type 4 Input Format and Sample Card Image

3.2.5 Card Type 5

Each card of this type contains the skill group name and the initial strength of that skill group. One card will be read in for each skill group. The total number of cards to be read is input by card type 4. (The example has thirty-five skill groups, so thirty-five type 5 cards are prepared). In order to minimize the discussion on this card type, only the first and last (thirty-fifth) cards are developed as examples. A maximum of twenty-eight characters can be used to name each skill group; abbreviations are often used.

Figure 3-5 contains the input format and sample card image for card types. The sample values used in the figure were obtained from Figure 2-3.

CARD TYPE = 5	SPECIFICATION OF SKILL GROUP NAMES AND INITIAL STRENGTHS				
ITEM	CARD COLUMN	FORTRAN FORMAT	FORTRAN VARIABLE	DESCRIPTION	SAMPLE VALUE
1	1 - 28	A28	TASK(1,1)	Skill Group Number 1's name	See below
2	29 - 33	I5	REG(1,1)	Initial strength	1
	34 - 75	42X		Blank	Blank
3	76 - 77	I2	ITYPE	CARD TYPE = 5	5
4	78 - 80	I3	ISEQ	Card Sequence Number	1
⋮	⋮	⋮	⋮	⋮	⋮
1	1 - 28	A28	TASK(35,1)	Skill Group Number 35's name	See below
2	29 - 33	I5	REG(35,1)	Initial strength	2
	34 - 75	42X		Blank	Blank
3	76 - 77	I2	ITYPE	CARD TYPE = 5	5
4	78 - 80	I3	ISEQ	Card Sequence Number	35

Card 35 /Assistant Tow GunnerΔΔ...ΔΔΔΔ2.........5Δ35|

Card 1 /Company CommanderΔΔ...ΔΔΔΔ1..............5ΔΔ1|

CARD TYPE 5 IMAGES

Figure 3-5. Card Type 5 Input Format and Sample Card Image

3.2.6 Card Type 6

Similar to card type 4, this card inputs the number of equipment types to be considered in the analysis. The specific equipment type input will be entered using card type 7. There are nineteen equipment types (nineteen cards) to be read in following this card.

Input formats and a sample card image appears in Figure 3-6.

CARD TYPE # 6	NUMBER OF EQUIPMENT TYPES (ONE CARD)				
ITEM	CARD COLUMN	FORTRAN FORMAT	FORTRAN VARIABLE	DESCRIPTION	SAMPLE VALUE
1	1 - 5	I5	NTASKS (2)	Number equipment types to be analyzed.	19
	6 - 75	70X	---	Blank	Blank
2	76 - 77	I2	ITYPE	CARD TYPE = 6	6
3	78 - 80	I3	ISEQ	Card Sequence Number	1

/ΔΔΔ19........... Δ6ΔΔ1

CARD TYPE 6 IMAGE

Figure 3-6. Card Type 6 Input Format and Sample Card Image

3.2.7 Card Type 7

Each card of this type contains the name of the equipment type, the initial strength of the equipment type and the times (in minutes) to repair light and moderate damage sustained by the equipment type. The total number of cards to be read in is contained in card type 6. (The example has 19 equipment types, so 19 type 7 cards are prepared.) In order to minimize the preparation discussion on this card type, only the first and last (nineteenth) cards are shown as examples. As with personnel skill titles, a maximum of twenty-eight characters are used to store each materiel title.

Figure 3-7 contains the input format and sample card image for card type 7. Sample values used in the figure were obtained from Figure 2-4.

CARD TYPE = 7	SPECIFICATION OF EQUIPMENT TYPE NAMES, INITIAL STRENGTHS, AND REPAIR TIMES FOR LIGHT AND MODERATE DAMAGE (ONE CARD/TYPE)				
ITEM	CARD COLUMN	FORTRAN FORMAT	FORTRAN VARIABLE	DESCRIPTION	SAMPLE VALUE
1	1 - 28	A28	TASK(1,2)	Name of equipment number 1	See below
2	29 - 33	I5	REG(1,2)	Initial strength	1
3	34 - 38	I5	REPTIM (1,1)	Minutes to repair light damage.	60
4	39 - 43	I5	REPTIM (1,2)	Minutes to repair moderate damage.	240
	44 - 75	32X		Blank	Blank
5	76 - 77	I2	ITYPE	CARD TYPE = 7	7
6	78 - 80	I3	ISEQ	Card Sequence Number	1
⋮	⋮	⋮	⋮	⋮	⋮
1	1 - 28	A28	TASK(19,2)	Name of equipment number 19	See Below
2	29 - 33	I5	REG(19,2)	Initial strength	153
3	34 - 38	I5	REPTIM (19,1)	Minutes to repair light damage.	15
4	39 - 43	I5	REPTIM (19,2)	Minutes to repair moderate damage.	60
	44 - 75	32X		Blank	Blank
5	76 - 77	I2	ITYPE	CARD TYPE = 7	7
6	78 - 80	I3	ISEQ	Card sequence number	19

Card 19 /Rifle 5.56ΔΔ..ΔΔ153ΔΔΔ15ΔΔΔ60.....Δ7Δ19|

Card 1 /Commander CarrierΔΔ...ΔΔΔΔ1ΔΔΔ60ΔΔ240..Δ7ΔΔ1|

Figure 3-7. Card Type 7 Input Format and Sample Card Image

3.2.8 Card Type 8

This card provides the input of the personnel transfer matrix. The sample case requires a thirty-five by thirty-five matrix. Since each card can only accommodate fifteen row values, each skill group for this example will require three cards. (The first through fifteenth value on the first card, the sixteenth through thirtieth value on the second card, and the thirty-first through thirty-fifth value on the third card.)

Figure 3-8 contains the input format and sample card images for the personnel transfer matrix. In order to shorten the summary table for card type 8, only the first row is shown (a total of 105 (3x35) cards are required). Note a "-1" is entered when a transfer is not permitted. Blank fields default to -1, which simplifies input of the transfer matrix. Zero values must therefore be input as a Ø. The sample data used here was obtained from Figure 2-6.

The personnel matrix is an NTASKS(1) by NTASKS(1) matrix. All zero and positive values represent the transfer time of the row skill to the column skill. Negative values indicate that the transfer is not allowed. NOTE: Blank inputs are assumed negative values. If the total time cost for a transfer is greater than or equal to the last time slice (see Card Type 3), the transfer is assumed non-feasible.

CARD TYPE = 8	PERSONNEL TRANSFER MATRIX (ONE SET OF CARDS/ROW: 15 VALUES/CARD) TIMES (MINUTES) FOR A ROW SKILL TO SUBSTITUTE FOR A COLUMN SKILL				
ITEM	CARD COLUMN	FORTRAN FORMAT	FORTRAN VARIABLE	DESCRIPTION	SAMPLE VALUE*
1	1 - 5	I5	TRANP(1,1)	Transfer time row 1 to col 1	0
2	6 - 10	I5	TRANP(1,2)	Transfer time row 1 to col 2	0
3	11 - 15	I5	TRANP(1,3)	Transfer time row 1 to col 3	0
. . . .	. . . .	. . . .	. . . .	. . . .	. . . .
15	71 - 75	I5	TRANP (1,15)	Transfer time row 1 to col 15	~~-1 or blank~~ 10
16	76 - 77	I2	ITYPE	CARD TYPE = 8	8
17	78 - 80	I3	ISEQ	Card Sequence Number	1
1	1 - 5	I5	TRANP (1,31)	Transfer time row 1 to col 31	~~-1 or blank~~ 0
2	6 - 10	I5	TRANP (1,32)	Transfer time row 1 to col 32	0
3	11 - 15	I5	TRANP (1,33)	Transfer time row 1 to col 33	0
4	16 - 20	I5	TRANP (1,34)	Transfer time row 1 to col 34	10
5	21 - 25	I5	TRANP (1,35)	Transfer time row 1 to col ~~34~~ 35	0
16	76 - 77	I2	ITYPE	CARD TYPE = 8	8
17	78 - 80	I3	ISEQ	Card Sequence Number	3

*Zeros must be input.

Card 3 ΔΔΔΔ0ΔΔΔΔ0ΔΔΔΔ0ΔΔΔ10ΔΔΔΔ0..........Δ8ΔΔ3

Card 1 /ΔΔΔΔ0ΔΔΔΔ0ΔΔΔΔ0ΔΔ.............ΔΔΔ10Δ8ΔΔ1

Figure 3-8. Card Type 8 Input Format and Sample Image

3.2.9 Card Type 9

This card provides the input of the materiel transfer matrix. The sample case requires a 19 x 19 matrix. Since each card can only accommodate 15 row values, each skill group for this example will require two cards. The input format for Card Type 9 is the same as Card Type 8, except that the number of cards required to input each row may differ.

CARD TYPE # 9	MATERIEL TRANSFER MATRIX (ONE SET OF CARDS/ROW; 15 VALUES/CARD) TIMES (MINUTES) FOR A ROW TYPE TO S STITUTE FOR A COLUMN TYPE				
ITEM	CARD COLUMN	FORTRAN FORMAT	FORTRAN VARIABLE	DESCRIPTION	SAMPLE VALUE
1-15			TRANM (NTASKS (2), NTASKS(2))	The materiel transfer matrix is an NTASKS (2) x NTASKS (2) matrix. This card set exactly parallels CARD TYPE 8 for each materiel line.	
			ITYPE	Card Type 9	9
			ISEQ	Card Sequence Number	1-38

CARD TYPE 9 IMAGE SAME AS CARD TYPE 8

Figure ?-9. Card Type 9 Input Format and Sample Image

3.2.10 Card Type 10

This card type inputs the number of essential teams that comprise the organization and the number of missions to be analyzed. In the sample case, 18 personnel and materiel teams and one mission are to be entered.

CARD TYPE # 10	NUMBER OF ESSENTIAL TEAMS AND NUMBER OF MISSIONS (ONE CARD)				
ITEM	CARD COLUMN	FORTRAN FORMAT	FORTRAN VARIABLE	DESCRIPTION	SAMPLE VALUE
				NOTE: All missions must be defined on the same set of available resources. Inventory items in excess of teams are spares.	
1	1 - 5	I5	NTEAMS	No. of teams	18
2	6 - 10	I5	NMISON	No. of missions to be considered.	1
	11 - 75	65X	---	Blank	Blank
3	76 - 77	I2	ITYPE	CARD TYPE = 10	10
4	78 - 80	I3	ISEQ	Card Sequence Number	1

/ΔΔΔ18ΔΔΔΔ1ΔΔΔ... ...10ΔΔ1|

CARD TYPE 10 IMAGE

Figure 3-10. Card Type 10 Input Format and Sample Image

3.2.11 Card Type 11

This card type is used to input the requirements for essential teams. The personnel requirements for teams one through NTEAMS are entered first, followed by the requirements for the materiel teams. Input for each team requirement is the increase from previous teams for each skill group or equipment type. Entering the requirements is made easier by using a system which takes advantage of the typical team build. Team requirements tend to have runs of the same number. For example, the first essential personnel team of the example (Figure 2-13) does not require any of the first six personnel skills, but does require one of the seventh skill, the carrier driver on line number seven. So, the first essential team has a run of six zeros before a non-zero requirement is reached.

The technique used to enter the data is to have a two value input system where the first value denotes the number of times the second value is to be repeated in the array. The first value is a multiplication factor and the second value is the associated requirement. In the example cited above, multiplication factor No. 1 is six and requirement no. 1 is zero because the first six consecutive skill groups have a requirement of zero. The number of multiplication factors (and corresponding requirements) depends upon the build of each particular team. The sum of the multiplication factors for any team must equal the number of skill groups or equipment types.

Figure 3-11 contains the card format and sample card image for Card Type 11. Only the first essential personnel team is shown, although there are eighteen personnel and materiel essential teams. By using this input system, only ten items are entered, rather than the thirty-five which would be necessary if each skill group required a value. The remaining personnel and materiel team requirements are entered similarly.

CARD TYPE = 11	REQUIREMENTS FOR ESSENTIAL TEAMS ORDERED BY PERSONNEL AND MATERIEL WITHIN MISSION (NO. OF CARDS VARY BY DATA ITEMS 15 VALUES/CARD ONE SET/TEAM)				
ITEM	CARD COLUMN	FORTRAN FORMAT	FORTRAN VARIABLE	DESCRIPTION	SAMPLE VALUE
				NOTE: Blank or Zero multiplication factor entry is assumed to be one (1), therefore, all fields (15) on a card are read and used until all tasks are counted. Blank requirement values default to zero values. Therefore, a blank card will be read as 15 zeros.	
1	1-2	I2	IPRND(1,1)	Multiplication Factor No. 1	6
2	3-5	I3	IPRND(1,2)	Requirement No. 1	0
3	6-7	I2	IPRND(2,1)	Multiplication Factor No. 2	1
4	8-10	I3	IPRND(2,2)	Requirement No. 2	1
5	11-12	I2	IPRND(3,1)	Multiplication Factor No. 3	13
6	13-15	I3	IPRND(3,2)	Requirement No. 3	0
7	16-17	I2	IPRND(4,1)	Multiplication Factor No. 4	4
8	18-20	I3	IPRND(4,2)	Requirement No. 4	1
2M-1	. .	I2	IPRND(M,1)	The Mth multiplication factor this card (maximum of 15 allowed)	11
2M	. .	I3	IPRND(M,2)	Requirement No. M	0
	76-77	I2	ITYPE	CARD TYPE = 11	11
	78-80	I3	ISEQ	Card Sequence Number	1

Δ6ΔΔ0Δ1ΔΔ113ΔΔ0Δ4ΔΔ111ΔΔ0....................................11ΔΔ1

or

Δ6ΔΔΔΔ1ΔΔ113ΔΔΔΔ4ΔΔ111ΔΔΔ (Blank requirement value default is zero.)

or

Δ6ΔΔ0ΔΔΔΔ113ΔΔ0Δ4ΔΔ111ΔΔ0 (Blank multiplication factor default is one(1).)

or

Δ6ΔΔΔΔΔΔΔ113ΔΔΔΔ4ΔΔ1ΔΔΔΔΔΔΔΔΔΔ etc. (Eleven zeros result from the remaining blank fields of the card.)

Figure 3-11. Card Type 11 Input Format and Sample Image

3.2.12 Card Type 12

For every PD set, this card type allows the input of up to seventy-two characters to title the AMORE output. The title of the sample case is "THE MECHANIZED INFANTRY COMPANY CONDUCTING THE ATTACK MISSION." This title contains sixty-two characters, including spaces between words. A good data processing habit is to center titles in given fields. Therefore the number of character spaces for the left and right margins would be (72-60)/2 = 5 characters each.

Figure 3.12 has the input format and sample card image for Card Type 12.

CARD TYPE # 12	NAME OR DESCRIPTION (OFTEN BASED ON ASSOCIATED PD SET) THIS RUN OF PROGRAM AMORE (ONE CARD PER SET OF PERSONNEL AND MATERIEL PDs)				
ITEM	CARD COLUMN	FORTRAN FORMAT	FORTRAN VARIABLE	DESCRIPTION	SAMPLE VALUE
1	1 - 72	18A4	TITLE(18)	Eighteen, four character elements allowing 72 characters of alphabetic title information; one title card must precede each PD set.	As in text
	72 - 75	X		Blank	Blank
2	76 - 77	I2	ITYPE	CARD TYPE = 12	12
3	78 - 80	I3		Number (always 1) Card Sequence	1

/Δ..ΔTHEΔMECHANIZEDΔINFANTRYΔCOMPANYΔCONDUCTINGΔTHEΔATTACKΔMISSION..Δ12ΔΔ1|

CARD TYPE 12 IMAGE

Figure 3-12. Card Type 12 Inout Format and Sample Image

3.2.13 Card Type 13

This card type inputs the probability of degradation (PD) for particular personnel skill groups and the delay time in minutes for the commander's decision. An examination of the PD set shown in Figure 2-16 reveals that there are four different probabilities of degradation for personnel (0.13, 0.14, 0.15 and 0.18). A type 13 card for each of these PDs (containing the line numbers for all personnel skill groups with that PD) will be prepared. The commander's decision time for personnel is included on each card.

Figure 2-13 contains the input format and sample image for card type 13. An example using a PD of 0.15 is shown in the figure. Each card can accommodate a maximum of 13 personnel line numbers, along with the PD and decision time. Note that two cards would be required to input the PD of 0.13 which applies to seventeen different skill groups. Note also that if a single PD and decision time applies to all skill groups, then only one card (with an entry of -1 for the first line number) is required.

CARD TYPE = 13	DEGRADATION PROBABILITIES AND DELAY TIMES FOR PERSONNEL BY SKILL GROUPS (ONE SET OF CARDS: 1 PD & DELAY TIME/CARD)				
ITEM	CARD COLUMN	FORTRAN FORMAT	FORTRAN VARIABLE	DESCRIPTION	SAMPLE VALUE
1	1 - 5	F5.0	TEMPPD(1)	Probability of Degradation (PD) for personnel skill groups to follow (real no.≤ 1.0)	.15
2	6 - 10	I5	ITEMPD	Personnel commander's decision (delay) time (min) to assess damage and initiate recovery actions.	5
3	11 - 15	I5	INDEX(1)	Line number of first personnel skill group having this PD (NOTE: If this PD applies to all skill groups, enter -1 in columns 14-15).	1
4	16 - 20	I5	INDEX(2)	Line number of second skill group.	10
5	21 - 25	I5	INDEX(3)	Line number of third skill group.	15
6	26 - 30	I5	INDEX(4)	Line number of fourth skill group.	16
⋮	⋮	⋮	⋮	⋮	⋮
15	70 - 75	I5	INDEX(13)	Last data line number this card. If continuation cards are needed, they must repeat the PD and delay time.	
16	76 - 77	I2	ITYPE	CARD TYPE = 13	13
17	78 - 80	I3	ISEQ	Card Sequence Number	1

/ Δ0.15ΔΔΔΔ5ΔΔΔΔ1ΔΔΔ10ΔΔΔ15ΔΔΔ16..........................13ΔΔ1|

CARD TYPE 13 IMAGE

Figure 3-13. Card Type 13 Input Format and Sample Card Image

3.2.14 Card Type 14

This card type, similar to card type 13, inputs the PDs for particular equipment types, and the delay time in minutes for the commander's decision. As discussed in section 2.2.3, the PD set for materiel contains PDs for light, moderate and severe damage and the commander's decision time. The PD's are in the cumulative format.

Figure 3-14 contains the input formats for card type 14. In addition, a sample card image with the cumulative PDs of 0.30, 0.22 and 0.08 is shown. The commander's decision time is ten (10) minutes for all equipment types. For materiel PD sets, a maximum of eleven line numbers can be input on each card. As with personnel, a -1 as the first line number indicates that the PD's and decision time apply to all equipment types.

CARD TYPE = 14	DEGRADATION PROBABILITIES AND DELAY TIMES FOR MATERIEL BY EQUIPMENT TYPE (ONE SET OF CARDS; 1 PD SET & DELAY TIME/CARD)				
ITEM	CARD COLUMN	FORTRAN FORMAT	FORTRAN VARIABLE	DESCRIPTION	SAMPLE VALUE
1	1 - 5	F5.0	TEMPPD(1)	Probability of light (or greater) damage (PD) to the equipment types with line numbers entered on this card.	.30
2	6 - 10	F5.0	TEMPPD(2)	PD for moderate (or greater) damage.	.22
3	10 - 15	F5.0	TEMPPD(3)	PD for severe damage.	.08
4	16 - 20	I5	ITEMPD	Materiel Commander's decision delay).	10
5	21 - 25	I5	INDEX(1)	Line number of first equipment type for this PD (NOTE: If this PD applies to all equipment types, enter -1.)	1
6	26 - 30	I5	INDEX(2)	Line number of second equipment type.	7
⋮	⋮	⋮	⋮	⋮	⋮
15	71 - 75	I5	INDEX(11)	Last data line number this card.	
16	76 - 77	I2	ITYPE	CARD TYPE = 14	14
17	78 - 80	I3	ISEQ	Card Sequence Number	1

/Δ0.30Δ0.22Δ0.04ΔΔΔ10ΔΔΔΔ1ΔΔΔΔ7.................................14ΔΔ1|

CARD TYPE 14 IMAGE

Figure 3-14. Card Type 14 Input Format and Sample Card Image

3.2.15 Summary of Input Requirements

The previously outlined input requirements are summarized in Figure 3-15. Each input deck must contain at least one card of each type. Card types 1, 2, 4, 6 and 10 will have only one card in the input data deck. The number of card images required for each of the remaining card types is determined by other input variables and can be determined from those variables. Card types 12, 13 and 14 form a set which may be repeated any number of times.

The card type and sequence number on each card is for user convenience in sorting card decks and is not required for model processing. The model will, however, print warning messages if these are not in proper order.

FIGURE 3-15. Summary of Input Requirements for AMORE

CARD TYPE	DESCRIPTION & FORMAT*	NO. OF CARDS
1	- Option Flags; No. of iterations, ITRATE; Choke data, SCHOKE; Assignment data, ASSIGN; Multiple Optimal solutions, MULTF; Use mean times, IMEANT; Input only, IONLY; (6I5)	1
2	- Number of times for capability calculations, NTIMES: (I5)	1
3	- *Times for capability calculations*; TIMES; (7F10.0)	As required 7 values/card
4	- Number of Personnel Tasks, NTASKS(1); (I5)	1
5	- Personnel Task Name & Authorized Quantity; (7A4, 3I5)	NTASKS(1) (1 card/ task)
6	- Number of Materiel line items; NTASKS(2); (I5)	1
7	- Materiel line item name, authorized quantity, light damage repair time, and moderate damage repair time; (7A4, 3I5)	NTASKS(2) (1 card/ line item)
8	- Personnel transfer times, in minutes. Zeros must be entered blank will default to -1; (15I5)	As required (15 values/card, NTASKS(1) values/task set, NTASK(1) sets)
9	- Materiel transfer times, in minutes. Zeros must be entered blank will default to -1; (15I5)	As required (15 values/ card, NTASKS(2) values/line item, NTASKS(2) sets)
10	- Number of teams and number of missions: NTEAMS & NMISON; (2I5)	1

FIGURE 3-15. Summary of Input Requirements for AMORE (Cont.)

CARD TYPE	DESCRIPTION & FORMAT*	NO. OF CARDS
11	- Team requirements, occurrence multiplier & quantity; (15(I2, I3)) Personnel requirements all teams } mission #1 Materiel requirements all teams } Repeat as required for NMISON missions. (All card type 11's must be numbered consecutively, do *not begin new sequence for multiple missions).*	As required, multipliers must sum to NTASKS() each team set. Blank multiplier defaults to one(1). Blank quantity value defaults to zero(0). All personnel teams then all materiel teams, repeat for each mission.
12	- Title to be associated with this PD set (18A4)	1 each PD set
13	- Probability of damage for personnel, delay time, task index; (F5.0, 14I5) (Task index of -1, PD applies to every task)	1 each unique PD or 13 line items (if all tasks have same PD, 1 card)
14	- Probabilities of damage for materiel total damage, moderate plus severe damage, and severe damage, delay time; line item index; (3F5.0, 12I5) (Line item index of -1, PD applies to every task) (REPEAT CARDS 12-14 FOR EACH PD SET - Sequence numbers for multiple PD sets must start over at 001 for each card type 12, 13, 14 set.	1 each PD or each 11 line items (if all line items have same PD, 1 card)

* All cards should have card type number in columns 76-77 and sequence number within type in columns 78-80.

3.3 PROGRAM EXECUTION

The AMORE model is installed for use at the Fort Leavenworth, Kansas, Data Processing Field Office (DPFO) computer facility. As with any computer program, program AMORE must be prepared and organized to adhere to certain sequential rules and specifications in order to properly execute on a specific computer. To do this, the user issues instructions to the computer via punched cards (batch mode) or remote terminal (time sharing mode). A sample of the UNIVAC required runstream is shown in Figure 3-15.

```
@RUN, [/options] [run-id, account, project-id, run-time/
                  deadline, pages/cards, start-time      ]

@ASG,A AMORE*AMORE.

@COPY,A AMORE*AMORE.AMORE/ABS-NEW

@FREE AMORE*AMORE.

@XQT

    Your AMORE input deck

@FIN
```

(NOTE: The symbol @ represents a 7-8 multi-punch)

Figure 3-16. Sample AMORE Runstream

This runstream allows the user to access the model and copy it into the temporary file structure assigned to his job. The FREE statement is required to release the permanent file from your job so that other users may access the model. The XQT statement causes execution of the model on the data stream immediately following and must proceed each data set when multiple executions (two or more complete AMORE input decks) are desired. The RUN card should conform to DPFO operating instructions.

Some users may desire to maintain a copy of the model in their own allocated file space. This may be accomplished by modifying the above runstream as follows:

Add before the COPY statement;

@ASG,A Your File.

Modify the COPY statement to;

@COPY,A AMORE*AMORE.AMORE/ABS-NEW, Your File.Your Element

Modify the XQT statement to;

@XQT Your File.Your Element

Any runs made subsequently should not include the statement @ASG,A AMORE*AMORE., the COPY statement or the FREE statement.

The DPFO computer at Ft. Leavenworth has several versions of the model with variations in the number of personnel tasks and materiel line items which can be accommodated. You should execute the smallest version which will handle your particular data set. All versions are included in the file AMORE*AMORE. In the COPY statement shown above use the element name as shown below for a particular version.

ELEMENT NAME	PERSONNEL SKILL GROUPS	MATERIEL LINE ITEMS
AMORE/NEW-SMALL	20	20
AMORE/ABS-NEW	35	25
AMORE/NEW-MED	35	35
AMORE/NEW-LRG	50	50
AMORE/NEW-XLRG	80	50

All versions are limited to the following maximum values of the parameters shown.

Total Individual Personnel plus Items of Equipment . 500

Number of Teams. 24

Number of Missions 3

Number of Times for Capability Assessment. 30

DAT

FILM