Research Note 80-33

DEVELOPMENT OF DATA PROCESSING STRATEGIES FOR POTENTIAL APPLICATION IN THE TACTICAL OPERATIONS SYSTEM (TOS) AND OTHER TACTICAL DATA SYSTEMS

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U. S. Army
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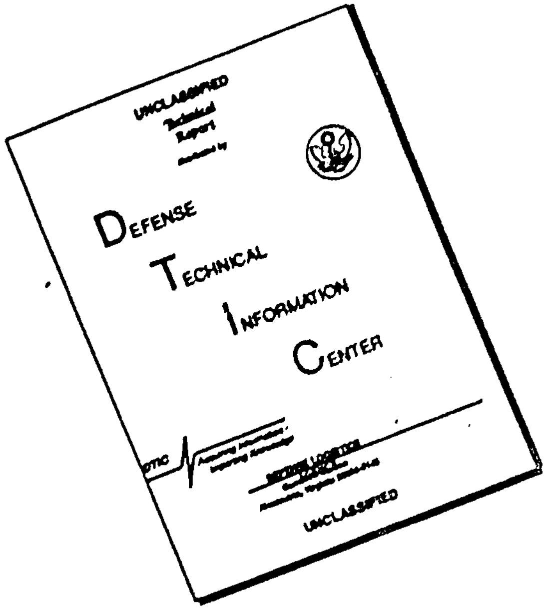

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This report describes research performed by the System Development Corporation (SDC) to develop improved procedures/data processing methodologies for forecasting battlefield personnel attrition and for reporting logistics status. Two active Army divisions provided information vis-a-vis how the two lattermentioned functions now are performed manually. This information provided the basis for the development of a data processing strategy concept which, if implemented in an automated tactical data system, should greatly improve the accuracy and timeliness with which the functions addressed can be performed.

Item 20 cont.

An experiment conducted with Command and General Staff College students confirmed that the timeliness and accuracy of the target functions would be significantly improved.

DEVELOPMENT OF DATA PROCESSING STRATEGIES FOR POTENTIAL APPLICATION IN THE TACTICAL OPERATIONS SYSTEM (TOS) AND OTHER TACTICAL DATA SYSTEMS

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FOREWORD

System Development Corporation (SDC) submits this document to the U. S. Army Research Institute for the Behavioral and Social Sciences (ARI) in accordance with contract number DAHC19-77-C-0018, "Continuation of Work to Optimize the Effectiveness of Command Post Functions: Development of Data Processing Strategies for Potential Application in the Tactical Operations System (TOS) and Other Tactical Data Systems." Mr. Steven R. Stewart, ARI Field Unit - Leavenworth, was the Contracting Officer's Technical Representative.

The research was performed by SDC personnel at Fort Leavenworth, Kansas during the period 8 February 1978 - 7 February 1979. Project members were Mr. B. R. Modisette, Project Manager, and Mr. G. W. Stevens. Mr. Modisette was replaced as Project Manager by Dr. Robert N. Parrish during July 1978. Santa Monica support for the project was provided by: Dr. Gloria Grace, Margaret E. Minton, Mr. Michael W. Lawless and Mr. Nicholas P. Moelter.

Documents produced for this project are:

TM-6155/001/00, "Research on Software Enhancements For Tactical Operating Systems: Literature Review," 1 August 1978

TM-6257/000/00, "Development of Data Processing Strategies for Potential Application in the Tactical Operations System (TOS) and Other Tactical Data Systems," 7 February 1979.

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Capt. Ronald J. Chiccehitto
Mr. Richard D. Loveall

ADMINCEN Liaison Officer

Maj. William J. Chantelau

Investigated FORSCOM Divisions

The thirty-two staff personnel who contributed their hospitality, time, and descriptions of their tactical operations.

U. S. Army Command and General Staff College at Fort Leavenworth

The Class Director's Office and the forty CGSC students who contributed their time and energy in support of the project.

The contributions of Mr. Paul E. McKeown of SDC to the project are gratefully acknowledged.

EXECUTIVE SUMMARY

Objectives

The primary objective of SDC's second year of effort under Contract DAHC-19-77-C-0018 was to develop data processing techniques to enhance the performance of priority command and control functions not currently supported by TOS or other tactical data systems. Subordinate objectives were to identify functions most in need of performance enhancement, analyze the data processing and information management procedures currently used for these functions, develop TOS software applications to enhance their performance, and conduct an empirical evaluation of the applications' utilities.

Selection of Applications

The initial effort consisted of extracting from the final report of the first year's work brief conceptual descriptions of 32 potential TOS software applications that promised enhancement of the performance of critical division command and control functions. These applications were screened to eliminate those that (1) were already under study by another contractor or a government agency, (2) were not critical to a division's mission or not performed frequently, or (3) did not support a primary staff agency. The applications that passed these screens were presented to TMO and ARI. Their review resulted in directon to SDC to further examine Personnel Attrition Prediction, Logistics Status Reporting, Areas of Interest, and Courses of Action. Subsequent discussions between ARI and SDC concluded that Areas of Interest did not involve sufficient data processing to require TOS support, and that Courses of Action required resources beyond those available to the project. ARI therefore recommended that SDC work on Personnel Attrition Prediction and Logistics Status Reporting, and TMO concurred with this recommendation.

Field Survey

With guidance from TMO, SDC conducted an in-depth analysis of the selected functions. During visits to two FORSCOM divisions, SOPs at all echelons were reviewed to identify required reports, their contents, instructions for their preparation, and their frequencies of submission. These reviews were followed by interviews with 32 administrative and logistics personnel. Additional data were obtained during visits to selected elements of CACDA and CATRADA at Fort Leavenworth. The data revealed several problems in performing the selected functions, which are highlighted below.

Personnel attrition prediction. The primary purpose of personnel attrition prediction is planning for replacements. However, attrition forecasts are sometimes considered in evaluating projected courses of action in tactical planning at the division level. Forecasts are typically prepared at higher echelons and delivered to divisions, although the divisions do develop their own estimates when operations are self-initiated or when they expect losses to exceed those projected by higher echelons. Units below divisions rarely are involved in personnel attrition prediction.

G1 personnel expressed satisfaction with attrition factors provided in FM-101-10-1. However, they stated that the current attrition prediction procedure is unwieldy, time consuming, and difficult to perform accurately. They further stated that the procedure lacks a method for predicting losses by MOS and grade, and that this is a serious shortcoming.

Logistics status reporting. The primary purpose of logistics status reporting is to provide information about asset availability and replacement needs. Basically, of ten classes of supply, only three (POL, ammunition, and major end items) are addressed in field SOPs, although any class will be reported if it becomes critical to the division's mission. Of these three, POL and ammunition are "pushed" items and play a minor role in tactical logistics reporting. Thus, the major reporting focus is on equipment.

Field survey data revealed two major problems in logistics status reporting: timeliness and accuracy. The former problem is inherent in report preparation and delivery times. The accuracy problem results largely from a combination of sequential reporting practices and human performance characteristics. There was no evidence that either of the divisions visited by SDC combined personnel and equipment data in a weapon systems context, although this concept is evolving within the Army.

Concept Development Design Considerations. In developing potential TOS software applications to support personnel attrition prediction and logistics status reporting, SDC tried to avoid major departures from the current manual procedures. Another developmental consideration was to limit individual skill requirements; personnel performing G1-S1 and G4-S4 functions are not always fully trained, so that potential applications must provide decision aids and relieve personnel of complex procedures. Additionally, the developmental process was restricted to applications that were compatible with existing TOS routines. Finally, SDC developed potential applications with due regard to "Weapon System Replacement Operations," an information management system in advanced stage of development, which is intended to facilitate the supply of critical tactical weapons and crews to field units.

An important consideration in developing the application was to view personnel attrition prediction and logistics status reporting as components of a system rather than as separate, discrete, and unrelated functions. That is, the attrition prediction function can be regarded as including not merely personnel but also tactically significant equipment as well. Similarly, the status reporting function for tactically significant equipment can be redefined to include the crew components of weapon systems. Then, the two components can be combined to form a personnel and weapon system status assessment function.

This approach permits attrition forecasts for division personnel in general and for both crew and equipment components of selected weapon systems. Meanwhile, it informs the commander and his staff of the status of significant weapon systems, and also provides a mechanism for refining new (and validating prior) attrition forecasts.

Conceptual description. The recommended TOS software application thus comprises two major compoents, a prediction component and a status reporting and prediction validation component. The prediction component itself consists of two sub-components, initial attrition prediction and revised attrition prediction. Initial attrition prediction begins with a complete personnel attrition forecast paralleling FM-101-10-1. Next, the application forecasts attrition for both equipment and crew components of weapon systems designated by the commander. In addition, the routine can provide personnel attrition forecasts by MOS and grade. In conformity with current practice, the routine is designed to provide a five-day forecast.

Although G1 personnel stated that current prediction factors are generally adequate, exceptions arise because of variances in parameters such as terrain, friendly and enemy strengths and compositions, and intensity of conflict. To compensate for such variances, the revised attrition prediction sub-component is designed to revise a prior forecast based on a divisions's actual experience. As losses and gains occur during an operation, the data are fed to the routine. Actual losses are compared to projected losses and new, temporary attrition factors are calculated. Assigned strength is adjusted by subtracting actual losses and adding gains, and then the routine generates a new forecast.

The data used to revise the forecast is provided by the weapon system status reporting routine. These data would also be useful for validating prior attrition forecasts. That is, differences between predicted and actual losses, expressed either as deviations or percentages, would provide a measure of the accuracy of past predictions. This aspect of the recommended application is essentially research-oriented in that the data might be used in developing an improved model for attrition prediction. Meanwhile, this portion of the application also alleviates the problems of timeliness and accuracy in equipment reporting that were discovered in the field survey. Data entered into TOS at the lowest feasible level become available immediately to all echelons equipped with IODs, thereby reducing the number of levels of sequential reporting. This approach also reduces the number of human links in the reporting system, and thereby reduces opportunities to introduce errors into the data base. Additionally, joint reporting of personnel and equipment components of weapon systems preserves the relationship of these components throughout the reporting chain.

Concept Validation

The concept of personnel and weapon system status assessment is both intuitively and logically appealing. Empirical data were needed, however, to test the feasibility and utility of the concept. The purpose of the experiment was to compare the recommended TOS application with current manual methods for performing the selected functions. The experiment was designed as a problem solving exercise. Participants serving as G1-S1 and G4-S4 staff officers responded to typical questions addressed to personnel administration and logistics elements. Problem types consisted of those that are easy to solve using current manual methods and those that are difficult or impossible to solve in a timely manner using such methods. Each problem type was broken down into two caegories, prediction problems and status problems.

Method. Experimental materials such as the data base, manual charts, simulated TOS displays, data collection procedures, problem solving scenarios, and the questions that drove problem solving activities were developed by SDC personnel with the aid and advice of a group of subject matter experts from the TMO. Forty students from the CGSC at Fort Leavenworth served as participants, working in two-man teams. Ten teams solved problems using a composite of the manual methods used in two FORSCOM divisions studied during the field survey, and the other ten teams solved the same problems using a simulated method derived from the recommended TOS application. Half of each ten teams solved problems in the context of a scenario depicting an attack operation followed by a defense operation. The other half had a scenario depicting a defense followed by an attack. Data collection sessions lasted approximately four hours per team. Each team provided two subjective ratings for each problem that they solved: (1) the value of the solution to that problem in terms of performing the G1-S1 and G4-S4 functions; and (2) the value of the problem solution compared with the effort required to obtain it.

Results. Results from the experiment demonstrated convincingly that the recommended TOS application could enhance performance of personnel and weapon system status assessment. Teams using the simulated TOS method were able to solve problems both more quickly and more accurately than could teams using the manual method. Moreover, the TOS method enhanced problem solving performance across four combinations of problem types and categories, and in the context of two tactical operations. Data from the two sets of subjective ratings indicated that the problems used in the experiment were relevant to G1-S1 and G4-S4 functions, and that their subjective values increased with the ease of solving them. Finally, data for the TOS method considered alone suggested a mild learning effect, indicating that learning to use the recommended application should pose no major problems.

Recommendations. On the basis of needs identified in the field survey and of results from the evaluation experiment, SDC recommends that TOS developers consider implementing the application described earlier. Implementation requirements are discussed in Appendix F.

Implications. The application would reduce the time and effort required to prepare attrition predictions, and extend the prediction capability to selected weapon systems, MOSs, and grades. It would also provide for revising forecasts on the basis of battlefield experience. Further, the application would permit validation of prior forecasts, and would alleviate problems of timeliness and accuracy in reporting of tactically significant weapon systems designated by the commander. It would not require any new manual reports or any modification to existing reports. It would increase personnel workload only to the extent necessary to extract data from existing reports for entry into TOS.

The application would require a new permanent file in TOS for storing constants and data for its software routines. Access to the UTO may be required for unit subordination data. However, application routines would not store data in other TOS files or conflict with existing software. To achieve the greatest utility from the application, data should be entered at the lowest feasible level, perhaps by means of inexpensive, hand-held input devices. Also, IODs should be allocated to the brigade and battalion trains for use by S1 and S4 personnel. These additions would increase the number of TOS users, and consequently increase input/output and data processing volumes. The extent of increase would depend on the frequencies of data reporting and of use of application routines.

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INTRODUCTION

BACKGROUND

The Army division of today is configured and operates in accordance with doctrinal concepts that have evolved over a period of several centuries. Methods of operation derived from these concepts have generally proved successful in battle, sometimes spectacularly so. Even so, there is concern within the Army that these methods may not suffice on the modern battlefield. For that battlefield is immensely more complicated than its precursors.

Its complexity is partly a result of the variety and intricacy of the weaponry provided by modern technology. It is also a result of an array of intelligence-gathering devices that has created a battlefield "information explosion" that rivals the one cited so frequently in the civilian literature. Today, military commanders and their staffs face a deluge of information that threatens literally to engulf them. Traditional command and control procedures, coupled with limitations on manpower availability, are simply unable to cope with it.

Recognizing the problem, the U. S. Army several years ago began a program to develop a computer system to assist with command and control information management and processing. The Tactical Operations System (TOS) is emerging as a product of that development program. TOS is intended to provide efficient and effective reception, processing, storage, retrieval, dissemination, and display of the tactical information required by the commander and his staff.

As part of the TOS development effort, the Army's Training and Doctrine Command (TRADOC) has responsibility for identifying user requirements for the system. This program is directed by the TRADOC System Manager (TSM) for TOS, a directorate of the Combined Arms Combat Developments Activity (CACDA) at Fort Leavenworth. The Army Research Institute for the Behavioral and Social Sciences (ARI) is providing research support to the TSM in regard to human performance capabilities, limitations, and feasible automatic data processing (ADP) augmentation associated with battlefield information systems.

Under contract to ARI, System Development Corporation (SDC) personnel have also been working in this area. In the first year of a planned three-year project, they developed a conceptual framework outlining in a systems context how TOS will support division staff operations. This framework was needed to provide the starting point for the development of TOS training materials.

Development of the conceptual framework began with a job and task analysis of the duties and functions performed by commanders and their staffs at the division, brigade, and battalion echelons. Levels of analysis ranged from the individual duty position (e.g., that of G2) to the element (e.g., the entire G2 section).

Analysis efforts focused primarily on the intelligence and operations elements of each echelon studied; however, the personnel administration and logistics elements at the division level also received attention.

Interpretation of the job and task analysis data led to a conceptual system description of TOS, showing how the system will support certain critical duties and functions performed by division command and control elements. At the same time, the analysis revealed other critical command and control duties and functions that are difficult or nearly impossible to perform using current manual methods, and which are not supported by existing or projected TOS software capabilities. Further examination of the latter duties and functions, for which a need exists to enhance performance, identified 32 functions that might profitably be supported by automatic data processing. For each of these functions project personnel developed a brief conceptual description of a potential TOS software application to provide that support. These descriptions, reproduced in Appendix A of this report, provided the starting point for the current year's effort.

OBJECTIVES

A major objective of that effort was further development of those applications that promised to overcome the most serious of the performance deficiencies discovered during the first year's work. Then, another major objective was to evaluate empirically the extent to which the applications improved performance of functions and duties they had been designed to support as compared to performance in their absence. More specifically, the objectives were to:

(a) identify specific applications that had been defined earlier to overcome deficiencies in performance of selected duties, functions and tasks that (1) were discovered during the first year's work and (2) appeared most susceptible to the support that improved data processing and information management procedures might provide, assign priorities to the candidate applications, and select one or more of the highest priority applications to serve as the focus for the remainder of the second year's effort;

(b) perform detailed analyses of procedures currently employed in the functional areas in which the highest priority performance deficiencies had previously been identified;

(c) survey data processing techniques and methodologies that might be suitable for improving information processing with the selected performance areas; and

(d) using one or more of the methodologies identified above, develop data processing strategies and evaluate those strategies by comparison with current TOS baseline performance (i.e., performance prevailing in the absence of those strategies).

This document constitutes the final report of the second year's activities under Contract DAHC19-77-C-0018, and reports the results of those activities.

ORGANIZATION OF THE REPORT

The remainder of the report is organized into three major sections which describe the activities undertaken to achieve the objectives described above. The first section describes the procedures required to select and to describe in greater detail the applications that would focus the remaining work during the current year. The second section describes the selected applications in conceptual terms. The final section documents an experiment conducted to evaluate the relative worth of those applications.

SELECTION AND DEFINITION OF POTENTIAL APPLICATIONS

IDENTIFICATION OF POTENTIAL APPLICATIONS

Conceptual descriptions of 32 potential TOS software applications were extracted from a portion of the report[1] of the first year's effort under this contract. Each potential application represented a possible solution to a problem in performing a particular duty or function by one of the division staff elements. The potential applications varied in complexity, and in comprehensiveness as well. Two examples follows; all 32 potential applications are presented in Appendix A.

Example: FSE Target Screen

The FSE target screen is an example of an application intended primarily to support one staff element. As TOS is presently conceived, G2 target information will pass automatically from TOS to TACFIRE. TACFIRE will

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1. Modisette, B. R., Michel, R. R., and Stevens, G. W. Initial Strategies for the Tactical Operations System (TOS) Support of the Command and Control Process. Volume 2: Description of TOS Functions for Division Elements. TM-6009/001/00, System Development Corporation, February 1978.

then analyze range and location data to determine whether the target is within range of DIVARTY and within its area of responsibility. Targets not meeting these criteria will be passed to the FSE for a further decision. This procedure potentially causes excessive use of communication channels. A potential TOS application would be a target screen based on DIVARTY's assets and area of responsibility. TOS would filter range and location data in each ESD message containing target information. The system would pass to TACFIRE only those targets within DIVARTY's engagement envelope. All other targets would be relayed to the FSE. The net result would be more effective utilization of communication channels.

Example: Automatic Distribution Matrix

The automatic distribution matrix provides an example of an application intended to support virtually every staff element. The application would distribute messages automatically to designated lists of users, eliminating the need for operator intervention. The matrix would contain a list of the characteristics that define each unique message type, and the distribution list for that type. The application would include message precedence, established automatically by criteria defined for each message type.

Task Considerations

In addition to a conceptual description of each of the potential applications, each was also described in terms of its "boundaries." That is, using information gathered from the first year's effort, project personnel assigned values to each potential application in terms of task considerations related to which and how many of a division's agencies it served, its suitability for computer implementation, and its importance to the division's mission. Specifically: these task considerations were:

(a) Number of echelons. Up to four echelons--corps, division, brigade, and battalion--could provide inputs to an application and/or receive outputs from it.

(b) Number of elements. As many as 22 elements of the division staff (e.g., G1, FSE, CMD, R&S) could provide inputs and/or receive outputs from an application.

(c) Primary staff agency. The primary staff agency (e.g., CMD, G4, FSE) that would benefit from the application.

(d) Task identification. A judgement by SDC personnel as to whether the application could best be performed manually (M), with partial TOS support (TS), or primarily by TOS (TA).

e. Criticality. The overall importance of the application to the success of a division's mission. Failure to perform the function supported by the application (1) could definitely jeopardize the mission, (2) could possibly jeopardize the mission, (3) could definitely affect an element's effectiveness but would not jeopardize the mission, (4) could possibly affect an element's effectiveness but would not jeopardize the mission, or (5) would have no effect either on an element's effectiveness or on the mission.

Table 1 shows examples of task consideration values assigned to two potential applications; Appendix B provides these values for all 32 applications.

TABLE 1

TASK CONSIDERATIONS FOR TWO OF THE 32 POTENTIAL APPLICATIONS

Potential Application	Task Considerations a	b	c	d	e
FSE Target Screen	1	3	FSE	TA	1
Automatic Distribution Matrix	4	22	G3	TA	4

Screening the Potential Applications

After describing the potential applications in terms of their task considerations, they were screened by project personnel on three different criteria to identify those that promised the greatest enhancement to TOS performance and that were not already the subject of attention from other agencies.

Screen 1: under study. Data provided by ARI and the TOS Manager's Office (TMO) served as the basis for this screen. Any potential application already being investigated or developed by a government agency or contractor received no further consideration.

Screen 2: criticality and frequency. Those applications not already under study were next examined for criticality, on the basis of the values assigned for the criticality task consideration described above. If an application had a value of 1 or 2, it passed the screen without further examination. If its criticality value was 4 or 5, it was eliminated from further consideration. Applications with a value of 3 passed this screen only if the function it supported was performed at least twice per 12-hour shift.

Screen 3: primary staff agency or task commonality. Applications that passed the first two screens passed this screen automatically if they directly supported either the intelligence or the operations elements, or both. Applications that directly supported either the administration or logistics elements passed this screen only if they provided critical information to the command and control decision making process.

An example of the outcome of the screening process appears in Table 2. Notice that the application in the table passed all three screens. For screen 1, a "No" (N) indicates that the application is not already under study and therefore merits further consideration. A "Yes" (Y) for the other two screens indicates that the application passed those screens. Appendix B presents the results of the screening process for all 32 applications. The appendix is organized to show first the applications that passed all three screens, and then those that failed one screen and therefore required no further consideration.

TABLE 2

AN EXAMPLE OF THE OUTCOME OF THE SCREENING PROCESS FOR POTENTIAL APPLICATIONS.

Potential Application	Task Considerations a	b	c	d	e	Screens 1	2	3
Develop FSE target Screen for Processing G2 Target Data to Divarty	1	3	FSE	TA	1	N	Y	Y

APPLICATIONS SELECTED FOR FURTHER INVESTIGATION

SDC personnel presented a table similar to Appendix B to representatives of ARI and TMO, recommending that only those potential applications that had passed all three screens be considered for further investigation. After discussion of TOS priorities, TMO selected the following potential applications as the most important of the candidates.

Personnel attrition forecasting. Develop a routine to compute personnel attrition forecasts.

Logistics status reporting. Develop a G4 information staff working file (SWF) and a routine to compare Battlefield Information Report (BIR) data to projected gains.

Areas of interest. Compare and recompute areas of interest based on changes in battlefield geometry (later further defined as Named Areas of Interest---NAI).

Course of action. Develop a course of action routine.

Subsequent meetings between ARI and SDC personnel compared available project resources to estimated resources required to perform tasks required by each of the four potential applications. ARI and SDC agreed that areas of interest did not involve sufficient data processing to merit further work and that courses of action required resources exceeding those available. However, they also agreed that available resources would permit work to develop (1) an improved model for personnel attrition prediction, and (2) methods to improve logistical status reporting. TMO concurred with these selections.

FIELD SURVEY OF CURRENT ATTRITION PREDICTION AND LOGISTICS REPORTING PROCEDURES

Purpose of the Field Survey

The purpose of the field survey was to obtain data on current manual procedures for personnel attrition prediction and logistics status reporting. Analysis of these data was expected to reveal problems encountered by personnel performing these functions that led to degradation in their performance. Then, specific automatic data processing strategies might be developed to eliminate, or at least alleviate, these problems.

Method

Efforts to develop a thorough understanding of current manual procedures for personnel attrition prediction and logistics reporting and their inherent problems began with a review of the Field Standing Operating Procedures (SOPs) for two FORSCOM divisions, to identify required reports in the two areas, echelons from which they are required, their contents, instructions for their preparation, and their frequencies of submission.

Two SDC personnel then made one-week visits to each of the two FORSCOM divisions. During these visits, they interviewed a total of 32 administrative and logistics personnel at the division, brigade, battalion, and company levels. Table 3 shows the distribution of the personnel interviewed among echelons and between administration and logistics elements within each of the two divisions. One individual interviewed administration personnel and the other interviewed those of the logistics element. A basic assumption was that real understanding of the attrition prediction and logistics reporting tasks required familiarity with the context in which they are performed as well as the procedures used to perform them. Therefore, interviewers did not confine their attention solely to the attrition prediction and logistics reporting functions. Instead, in the time available, they tried to learn as much as possible about those administration and logistics functions that relate to tactical decision making and operations. Specifically, for each function, SDC personnel sought to:

(a) obtain detailed information about the data required to perform a task;

(b) identify the practical limits and utility of the data in terms of its age, reliability, and level of detail;

(c) identify current sources of data, report formats, frequencies of submission, and report routings;

(d) describe current data processing techniques and their limitations; and

(e) identify the users of the data and the uses they make of it.

TABLE 3

THE DISTRIBUTION AMONG ECHELONS OF PERSONNEL INTERVIEWED AT TWO FORSCOM DIVISIONS.

	Division 1		Division 2	
Echelon	G1/S1	G4/S4	G1/S1	G4/S4
DIVISION	4	4	8	1
BRIGADE	1	1	1	1
BATTALION	2	2	1	1
COMPANY	3*	3*	1	1

*The same individuals were interviewed for both the admin and log areas.

The recording sheet illustrated in Figure C-1 of Appendix C provided the structure for each interview. The interviewer simply asked for the information required to fill in each space. He completed a separate recording sheet concerning each report for which the individual being interviewed had responsibility. Briefly, the requested information about each report included its name, the contents of the report, the frequency of reporting (e.g., hourly, once per shift, daily, on demand, only when a change of status occurs), who prepared the report, where the report was prepared, how much time was consumed in preparing it, the steps required for preparation, and the physical act that terminated the reporting procedure (e.g., transmitted to another organization, posted to a file).

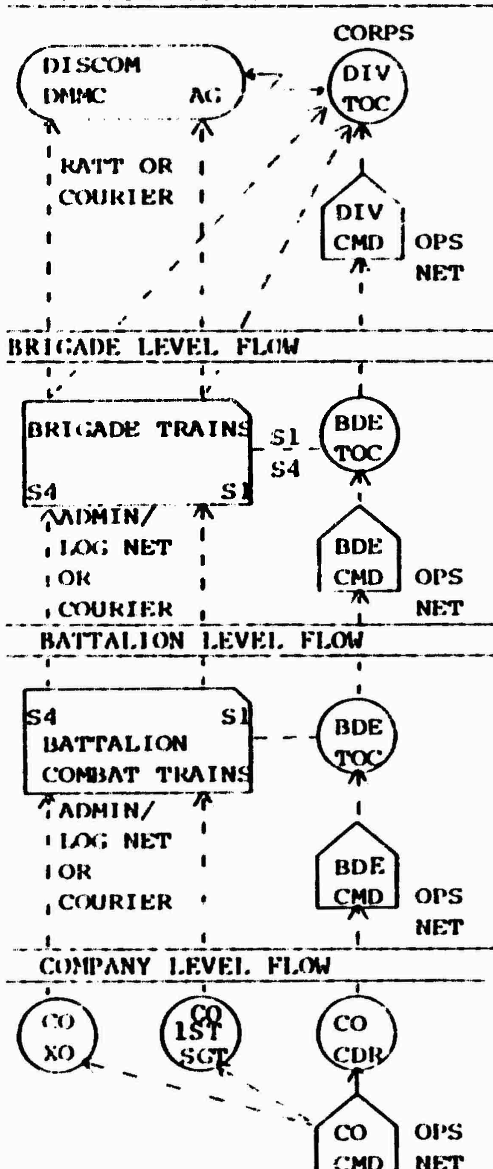
To avoid influencing interviewees' responses interviewers did not show data recording sheets from one echelon to anyone at another echelon. Thus, for example, personnel at division and battalion did not see data provided by those at brigade.

Results

The review of SOPs indicated that the two divisions required substantially the same kinds of data to be reported, from essentially the same echelons. However, the titles of reports often differed, as did their formats. Also, in some instances, the same types of data were transmitted through different reports in the two divisions. The frequencies of report submission differed in many cases. One division required daily submission for most reports; the remainder were submitted only on demand. The other division, by contrast, required reports to be submitted only when necessary to document changes in status.

Data flow. Data flows also differed in some details between the two divisions. Furthermore, within a division data flows might differ in maneuver units when compared to support or special units, or from one report to another. These observations notwithstanding, data generally flow in much the same ways in both divisions (Figure 1). Note in the figure that administrative and logistics data can move over both the command/operations and the administrative/logistics reporting chains. Of course, routine reports are not typically transmitted over the command/ops chain; only when admin/log data have immediate tactical implications (significant losses to personnel or equipment, for example) do they move over the chain. Still, there is duplicate reporting, at least to some extent. Moreover, according to some of the personnel interviewed, this duplicated information frequently enters the two reporting chains at different times and with differing accuracies. Among other consequences, this sometimes results in contradictions in the data presented, for example, by the G3 and G4 during commanders' briefings.

Figure 1 also shows parallel reporting channels within the admin/log chain. That is, the Company Executive Officer (CO XO) reports equipment data to the



LEVEL	COMMENTS	PREPARATION/ TIMING*
DIVISION LEVEL FLOW	- Collation of data is displayed by Bde by Bn or TF. - Only level where Class III & V data are exchanged. - Reports to corps were prepared by DISCOM (DMC) and reviewed by the G4; G1 did prepare the PERSREP for corps. - Lengthy G4 preparation and timing noted in the next column is due to sorting out data discrepancies.	<u>G4</u> 30 min to 4 hours <u>G1</u> 15 min to 30 min
BRIGADE LEVEL FLOW	- Collation occurs at this level, Bn data retains its identity. - Principle inputs are by admin/log net or courier; outputs are by RATT or courier. - Critical items are passed to TOC and next higher HQ ASAP. - Collected data are source for CDR briefing.	<u>S4</u> 15 min to 60 min <u>S1</u> 30 min
BATTALION LEVEL FLOW	- Major consolidation and record keeping occurs - reports organized at the Bn or TF level. - Admin/log net and courier are the principle sources of communication. - Critical items of interest are passed to TOC and higher HQ ASAP. - Data collected represents the principle source for CDR briefing.	<u>S4</u> 15 min to 60 min <u>S1</u> 30 min to 120 min
COMPANY LEVEL FLOW	- Only minor record keeping occurs. - Real Time reporting is encouraged. - Admin/log net and courier are principle sources of communication.	<u>XO</u> 15 min to 30 min <u>1st SGT</u> 15 min to 30 min

*The minimum and maximum times required by the staff section to prepare any of its reports.

Figure 1. A general representation of data flow within two FORSCOM divisions.

battalion S4. Meanwhile, the Company 1st Sergeant (CO 1ST SGT) reports personnel data to the battalion S1. Thereafter, the data continue to be reported separately as they move up the reporting chain. In some, or perhaps many, cases, this separation of personnel and equipment is inconsequential, but not in the case of crewed weapons. Consider the M60 system, for example. One may think of that system being composed of five major components: tank, commander, gunner, driver, and loader. One of these components, the tank, is reported through the logistics channel, while the other four are reported through the administration channel. Additionally, in tactical reporting, the personnel components are not identified as to crew positions. As a consequence, the reporting system provides information to higher headquarters about the status of weapon systems only in the Battlefield Information Report (BIR), which is an operations rather than an administration/logistics report. This point is elaborated later.

Attrition prediction. The major purpose of attrition prediction appears to be planning for replacements, although loss forecasts are used sometimes in evaluating projected courses of action. Echelons below division level typically are involved only indirectly in attrition prediction, that is, as sources of data required for the procedure. There are exceptions; one battalion S1 reported that occasionally he prepared an attrition forecast for his commander. Since no documented attrition prediction procedure for battalions was available to him, he used division loss factors from FM 101-10-1 (a potentially dubious procedure) and his battalion's assigned strength. In the main, however, personnel attrition forecasts are prepared at higher echelons and then delivered to the divisions. Division personnel typically prepare estimates only for operations in which losses are expected to exceed those predicted by higher echelons, or in case of a division-initiated operation. Personnel at both divisions said that they therefore perform attrition prediction procedures infrequently (nonetheless, they regard the attrition forecasts that they do prepare as being highly important). When they do, they use procedures and tables in Section 5-9 of FM 101-10-1.

A detailed description of attrition prediction procedures is provided in Appendix C.

Logistics status reporting. Logistics personnel in both FORSCOM divisions agreed that no one class of supply is inherently more important than the others, because a sudden acute shortage of virtually any class (probably excepting VI and X) can threaten the success of an operation. Nonetheless, they indicated

2. FM 101-10-1, Staff Officers' Field Manual: Organizational, Technical and Logistics Data. Headquarters, Department of the Army, July 1976.

that Classes I, II, IV, VI, VIII, IX, and X seldom, if ever, impact tactical decision making or operations significantly. These classes were therefore eliminated from further consideration, as described in Appendix C.

Because Class III (POL) and V (ammunition) are push driven (as described in Appendix C) they normally have relatively little impact on tactical reporting. Further, because of the relatively short reporting chain, there are comparatively fewer problems in reporting POL and ammunition than in reporting Class VII (major end items), discussed immediately below. For these reasons, Classes III and V did not seem to require inclusion in future versions of TOS.

That Class VII items received the greatest interest and attention in both the FORSCOM divisions is scarcely surprising. The major weapons and support equipment comprising this class have obvious tactical importance, and their importance is reflected in their prominence in the logistics reporting system. While individual units keep their own records of several classes of supply, formal reports originating in the companies focus on Class VII items. A detailed description of current logistics reporting procedures is presented in Appendix C.

G4 personnel agreed that their greatest and most pressing problems were to obtain timely information that is accurate. The problem of timeliness has two aspects. First is the time required to receive the data from lower echelons and then to assemble the data and prepare the report. Second is the time required to transmit reports from one echelon to the next higher echelon. Combined, preparation time and sequential reporting can consume as many as 13 hours between the company and division levels.

The problem of accuracy appears to stem from a combination of sequential reporting and human performance. That is, data are compiled at the company level, then relayed through the battalion and brigade to division. At every level, human beings are required to transcribe, consolidate, transmit, or in some other fashion manipulate the data. Of course, every human being in the reporting chain is a potential source of error, through omission, commission or transposition.

Ancillary Data

After the visits to the FORSCOM divisions, SDC personnel also visited selected elements of CACDA and the Combined Arms Training Developments Activity (CATRADA) at Fort Leavenworth to determine whether personnel attrition models existed or were being developed for systems such as CATTS, Division War Games (DIVWAG), and Computer Assited Map Maneuver System (CAMMS). In each case, the agency used personnel and weapon kill probabilities. However, these data were generated to further the purposes of tactical war game situations. They were predicted on relative positions of weapon systems to one another, rates of fire, and protection factors. No agency had a model for forecasting losses to personnel in anticipation of an impending operation.

SDC personnel also visited liaison officers assigned to CACDA from the Logistics and Administration Centers (LOGCEN and ADMINCEN) to inquire about their centers' efforts regarding personnel attrition forecasting and logistics reporting. Neither could offer anything new in regard to personnel attrition prediction; however, they did bring to SDC's attention two new concepts in personnel and weapon management: "STUBBY PENCIL" and "WEAPON SYSTEM REPLACEMENT OPERATIONS." The former is a newly-developed wartime personnel accounting system, and the latter is a newly-developed information management system designed to expedite the flow of critical tactical weapons and crews, and thereby assist corps and division commanders to concentrate combat power. Both concepts allegedly have been approved by TRADOC and forwarded to Department of the Army with a recommendation that they be approved. Relevant portions of these concepts are discussed later in this report, as they relate to proposed TOS applications.

CONCEPT DEFINITION

RELEVANT CONSIDERATIONS AND CONSTRAINTS

Current Manual Methods

Although the ultimate purpose of both the G1 and G4 elements is to support tactical operations, many of their activities are ancillary to that purpose. For example, many personnel records have little impact on tactical operations, and the same is true of many logistics records. Because TOS is a tactical system intended to support the command and control process rather than either a personnel or logistics system, SDC project personnel never considered using TOS to supplant current data reporting and record keeping methods. The intent rather was to extract from current reports those data items that are important to tactical decision making and operations. Thus, since the current manual methods for reporting administration and logistics data will continue to function largely as before, project personnel sought to inflict as little impact on those methods as possible. The goal was to obtain the necessary data with minimal disturbance to the existing system and minimal addition to the workloads of the personnel in the system.

Personnel Experience

Observations of the two FORSCOM divisions suggested that personnel performing the S1-G1 and S4-G4 functions are not always specialists in these areas or fully trained in them. Therefore, any applications developed for either area should, as much as possible, provide easily used decision aids and relieve personnel of the need to perform complex procedures.

Compatibility With Existing Features of TOS

Specifications for a number of applications have already been developed for TOS. Therefore, any new applications should be as compatible as possible with existing applications. There should be no interference with those applications, and new applications should not impose any requirements on TOS users that conflict with those imposed by existing applications. Further, display formats should be compatible in design with existing formats.

STUBBY PENCIL and Weapon System Replacement Operations

At the time that SDC personnel first became aware of them, STUBBY PENCIL and Weapon System Replacement Operations were already in advanced stages of development and showed promise of winning eventual approval. Therefore, any application for personnel attrition prediction or logistics status reporting must be designed with these concepts in mind, to avoid possible conflicts at a later date.

POSSIBLE SOLUTIONS

Personnel Attrition Prediction

G1 personnel expressed satisfaction with the attrition factors provided in FM 101-10-1 (Appendix C). Even so, SDC personnel considered the possibility that technological advances and changes in tactical doctrine might have rendered those factors obsolete. A literature review conducted for this project[3] cited operations research (OR) reports describing a number of forecasting models, and combat and inventory models that contain prediction functions. Some of these models show promise for future implementation as personnel attrition prediction algorithms. Another potential approach would entail investigating the possibility of combining or weighting weapon kill probabilities and other functions used in war game environments to produce a new personnel attrition prediction algorithm. Finally, one could try to work backward from

3. Lawless, M. W., Minton, M. E., and Grace, G. L. Research on Software Enhancements for Tactical Operating Systems: Literature Review. Interim Technical Report TM-6155/000/00. System Development Corporation, 1 August 1978.

the attrition factors in Tables 5-8 and 5-9 of FM 101-10-1 to develop an algorithm using parameters such as terrain and strengths and compositions of friendly and enemy forces, each with an appropriate weighting factor associated with it. Then, as experience accumulated, the weighting factors could be adjusted to provide an improved model.

Each of these approaches has merit, and none should be discarded out of hand. Still, each requires extensive development and/or testing, including gathering, reducing, and analyzing large amounts of data for purposes of validation. Such efforts were beyond the scope of this project. For example, experience at the Air Defense Command (ADC) alone illustrates that development efforts of this kind can easily consume many man-years.

Logistics Status Reporting

The problem of accuracy of information received by the G4 might be solved or at least alleviated by improvements to the current manual method. For example, standard printed reporting forms might be redesigned, instructions for completing the forms might be rewritten for easier understanding, and reporting procedures might be simplified or otherwise redesigned. Project personnel considered this possibility only very briefly, however, because it contributes nothing to the solution of the equally important problem of the timeliness of the information received by the G4. Indeed, within the context of manual reporting, the only solution to the timeliness problem seemed to be a wholesale redesign of the admin/log communication system, a solution clearly not feasible within the funding level of this year's effort.

Genesis of the Application

A primary key to solving problems inherent in current personnel attrition prediction and logistics status reporting is to view them as components of a system rather than as separate, discrete, unrelated functions. Recall the observation earlier in this report that separate reporting of personnel and equipment creates a "system problem," i.e., information about the status of systems is lost. In the same vien, predicting personnel attrition by current methods overlooks the fact than many of these personnel are weapon crewmen. Ignoring their weapons during attrition prediction ignores the future status, not only of the weapons themselves, but also of the weapon systems of which they and the crewmen are components.

Evidently, then, the solution requires broadening the concept of attrition prediction to include not merely personnel, but also tactically significant weapon (and possibly support) systems as well. To do so would permit the attrition prediction function to forecast the future status of the division's critical tactical assets (i.e., major weapon systems) in the same way that other forecasting models predict the outcome of a particular tactical operation or the consequences of a given enemy action.

By the same token, logistics status reporting for the tactically significant Class VII items could be redefined as weapon system status reporting. Then, the functions would serve two purposes. First and most important, it would inform the commander and his staff of significant weapon systems status. But at the same time, with little or no additional cost or effort, it could also serve as a mechanism for testing forecasts generated by the attrition prediction function.

If the two functions, prediction and reporting, are regarded as components according to the system concept, then they form what might be called a system to assess the status of selected personnel and equipment items. One component predicts the future status of tactically important weapon systems, and the other component provides current status information and simultaneously validates or invalidates previous status predictions.

CONCEPTUAL DESCRIPTION OF THE APPLICATION

The recommended application comprises two major components, a prediction component and a status reporting and validation component. The prediction component futher consists of two sub-components, attrition forecasting and revised forecasting. These components and sub-components are described briefly at the conceptual level here; technical details and their implications are described and discussed in Appendix F.

Attrition Prediction

Attrition forecasting begins with the complete personnel attrition forecast described in FM 101-10-1 and summarized in Appendix C of this report. Automation of this function relieves G1 personnel of the tedious work of following an unwieldy procedure and permits the production of forecasts more quickly and more accurately than do manual methods. Using the completed personnel forecast, the sub-component then goes on to forecast attrition for both personnel and equipment of weapon systems specified by the commander, a procedure not currently available. Results from the field survey suggest that the application should focus on major weapon systems and perhaps tactically significant support systems. However, there is nothing in the concept to prevent the commander from designating any system he desires for inclusion in the data base.

This weapon system attrition prediction routine responds to the need expressed by G1 personnel for a capability to forecast losses by MOS and grade in addition to forecasting losses of designated weapons. For example, the routine can forecast the numbers of M60 tanks and tank crewmen the division can expect to lose during an operation. Of course, tank crewmen have the same MOS, so the routine predicts losses for that MOS. At the same time, the routine breaks down estimated tank crewmen losses into numbers of losses of commanders, gunners, drivers, and loaders. Since crew positions are associated with different skill levels within the MOS and hence with different grades, the capability exists to forecast losses by grade.

The attrition forecasting routine (and the revision routine described next as well) is designed to provide a forecast limited to 5 days. This limitation conforms with present practice. In principle, however, there is nothing to prevent programming the routine to change the 5-day limitation to any period desired.

Revised Attrition Prediction

The attrition factors in FM 101-10-1 are the result of averaging across divisions and across factors such as terrain, geographic location, climactic conditions, and so on. Thus, the experience of a single division, conducting a particular operation in a specific situation, is unlikely to match its predicted experience. Though G1 personnel stated that predictions were adequately accurate, doubtless there would be cases where this would not be true because of unusual variances in factors such as terrain, friendly versus enemy strengths and/or compositions, and intensities of conflict.

To compensate for such variances, the recommended application includes a sub-component to revise a personnel attrition and weapon system forecast based on a division's actual experience. As losses and gains are incurred during an operation, the data are fed to the routine. Actual losses are compared to projected losses and new, temporary attrition factors are calculated. Assigned strength is adjusted by subtracting actual losses and adding gains. The routine then generates a new forecast using revised attrition factors and the adjusted assigned strength. The revised attrition forecast could be generated as often as desired during the course of an operation, incorporating more and more of the division's actual experience.

Status Reporting and Validation

The data used to compute new attrition factors for revised attrition forecasts are, of course, the same data used to inform the commander and his staff of the status of tactically important weapon (and if desired, support) systems. By entering the data into TOS, and programming the machine to process it in ways described in Appendix F, this portion of the proposed application would alleviate the problems of timeliness and accuracy in Class VII reporting that were discovered during field data collection. That is, data entered at, say, battalion level would become available immediately at division level, thereby reducing the time delay induced by sequential reporting[4]. At the same time, reducing sequential reporting, by removing the number of human beings in the reporting syste, reduces the number of error sources. Meanwhile, letting the machine do the data processing frees human beings to perform tasks other than "number crunching." And finally, joint reporting of human and machine components of weapon systems preserves the relationship of these components throughout the reporting chain.

The same data used for revised attrition forecasts and for status reporting would also be valuable for validation of attrition forecasts. Differences between predicted and actual losses, expressed either as deviaions or percentages, would provide a measure of the accuracy of prediction. This aspect of the application is essentially research-oriented. That is, predictions, revised predictions, and actual losses could be analyzed over a period of time. The outcome might well be a new model for attrition prediction. At the least, attrition prediction factors from FM 101-10-1 could be upgraded.

CONCEPT VALIDATION

PURPOSE

The concept of personnel and weapon system status assessment is both intuitively and logically appealing. Nevertheless, empirical data were needed to test the feasibility and usefulness of that concept. Therefore project personnel conducted an experimental evaluation of the recommended application. The purpose of the experiment was to compare TOS performance augmented by the application with TOS baseline performance (i.e., performance without the application). Because neither the TOS computer nor the requisite software were available for the experiment, this purpose translated effectively to a comparison of performance using the application to performance using current manual methods.

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4. This positive aspect of the proposed application nevertheless has negative implications for hierarchial review, and for the S1 and S4 at the battalion and brigade levels. These implications are discussed under "Implementation of the Application."

The portion of the application that calculates revised attrition predictions had not been completely worked out prior to the beginning of the experiment, and therefore could not be tested. Because the routine's outputs were expected to be essentially the same in format as those of the initial prediction routine, and because such revised predictions cannot be made using current manual methods anyway, inability to test the revised attrition prediction routine was not serious.

Objectives of the Experiment

The major objective of this experiment was to compare problem solving performance using manual methods with such performance using a "TOS method," i.e., the application. That is, the purposes of attrition prediction and logistics status reprting include informing commanders and operations staffs of the availability of assets and informing higher echelons of the need for replacements. These tasks may be considered as problem solving tasks. The problem is initiated by a query or a reporting requirement, and involves gathering problem-related information. The problem is solved when the information is delivered to the appropriate individual or section.

To achieve the major objective, the experiment had four subordinate objectives, namely to determine:

(a) which method provided the most rapid problem solving performance;

(b) which method provided the most accurate problem solving performance;

(c) whether the method employed in problem solving affected the user's opinions regarding the value of the problem solutions he obtained; and

(d) whether the method employed in problem solving affected the user's opinions regarding the value of the problem solutions he obtained as compared to the effort he had to put forth to obtain them.

METHOD

Participants

Forty students at the Command and General Staff College (CGSC) volunteered to participate in the experiment. All were American Army officers: 38 held the rank of major and two were captains. Each participant completed a background information form (Figure D-1 in Appendix D.) Eighteen of the officers had from eight to 32 months experience as battalion or brigade S1s. One had 11 months experience as an assistant division G1, and another worked for 42 months in personnel management at DA level. Eleven had from 12 to 36 months experience as battalion S4s. The remainder had served as company commanders. Seven had attended courses lasting from one to 11 weeks in some area of administration or logistics.

Participants solved problems in pairs, with one serving as S1-G1 and the other as S4-G4. In forming the two-man teams, an effort was made to assign individuals to job roles according to relevant experience. Officers without personnel administration or logistics experience were assigned to teams at random. During experimental sessions, participants worked with data at the battalion, brigade, or division level, depending on the specific problem. At their option, they worked independently with each solving problems appropriate to his job role, or else they worked cooperatively.

By agreement with the CGSC, each participant was available to the experiment for a maximum of four hours.

Experimental Design

A valid comparison of the two methods required testing them under a variety of different conditions to ensure that results generalized to more than a single set of conditions. Therefore, in addition to the major independent variable of methods, the experiment included different problem solving situations, types of operations, types of problems, and categories of problems. Methods and situations were "between participant" variables; the others were "within participant" variables. The five independent variables were arranged in a hierarchial design (Table 4).

Development of Experimental Materials

In addition to the participant background information form, two rating scales (Figure D-2 in Appendix D) were developed for use by participants in expressing their opinions of problem solution values and of values compared to effort required to obtain them. All other materials described below were developed with the aid and advice of a group of subject matter experts from TMO. These materials are illustrated in Appendix D.

Types of operations. Two operations were described: in one an American mechanized division would defend itself from an attacking enemy force, and in the other the division would itself attack an enemy position. The participants' problem solving activities involved preparation for one of these operations.

TABLE 4. EXPERIMENTAL DESIGN FOR A COMPARISON OF TWO METHODS OF DATA ORGANIZATION AND PRESENTATION FOR G1 and G4 PROBLEM SOLVING.

			Manual		TOS	
	Problem Categories	Problem Types	Prob. Sit. 1 T_1-T_5	Prob. Sit. 2 T_6-T_{10}	Prob. Sit. 1 $T_{11}-T_{15}$	Prob. Sit. 2 $T_{16}-T_{20}$
Defense	Stat	"CONV"				
		TOS				
	Pred	"CONV"				
		TOS				
Attack	Stat	"CONV"				
		TOS				
	Pred	"CONV"				
		TOS				

TABLE 4. Continued

Notes:

1. The manual methods are the methods currently in use. Since these methods vary somewhat from one division to the next, the study employed a composite based on observations of two FORSCOM divisions.

2. Prob. Sit. = Problem solving situation.

3. "Conv" = "Conventional" problems. These are problems that can be solved directly from data bases developed by current manual methods, or solved with minimal computation or requests for clarification.

4. TOS = (in the experimental design) TOS problems. These are problems that require moderate or extensive computations, or that require interrogation of lower echelons. Thus, they are problems that are not easily solved from data bases developed by current manual methods.

5. Stat = Status. Problems in this category require the G1 or G4 merely to provide information about the current status of the division.

6. Pred = Prediction (forecasting). Problems in this category require the G1 or G4 to forecast the attrition consequences to personnel and logistics if a given action is taken.

Problem solving situations. Three problem solving situations were prepared. One was a sample used for training purposes. The other two, used for actual data collection, were constructed by combining the two operations described above. In one situation, defense was followed by attack, and in the other, attack was followed by defense. The situations were arranged in this way because data collection was carried out in two phases, with one operation providing context for each phase. The two situations counterbalance the two operations across the data collection phases.

Problem types. The two types of problems may be distinguished as follows. There are many problems that a given staff officer may wish to solve. Some of these problems require information which is immediately available or readily obtainable. These problems, of course, are solved whenever necessary. However, other problems require information that is so difficult or time-consuming to obtain under current methods that either the problem's solution is not worth the effort, or else it is obsolete when it finally is obtained. These problems are never or seldom solved, for the simple reason that officers do not even attempt them unless directed by higher authority. Further, higher authority realizes that timely solutions to such problems are impossible or nearly so to obtain, and consequently seldom directs that they be attempted. In this report, the former type is labelled "conventional" problems and the latter type is labelled "TOS" problems. These two types were further broken down into two categories, as follows.

Problem categories. Half of the problems of each type described above were ones that required the participant merely to determine the status of personnel or of a particular weapon system, in this case the M60A2 tank system or the M220A1 TOW system. Such problems could deal with the status of any echelon from company to division. The other half of the problems required the participant to make a prediction of personnel or weapon system attrition. These problems concerned only the division level. In the manual method, participants computed attrition forecasts using tables and procedures in FM 101-10-1 and/or the procedure illustrated in Table D-3 of Appendix D. In the TOS method, forecasts could be read directly from a simulated computer display.

Displays. For participants using the manual method, information sources consisted of charts simulating those used in two FORSCOM divisions. If these charts did not contain the information required for a particular problem, the participant could write a note to the experimenter. The experimenter had a complete problem solving data base, and he could locate the information requested on the note and provide it to the participant. For participants using the TOS method, simulated computer displays were prepared. Every information item in the data base appeared in at least one of these displays.

Procedure

A field-grade officer from the TMO briefed each group of participants as soon as they were assembled at the laboratory. The purpose of his briefing was to give the participants an overview of the experiment, and by his presence to assure them that it had a serious purpose for TOS. He described TOS briefly and explained the purpose of the experiment. He then advised the participants that several assumptions had been made to control the scope and duration of the experiment, such as, for example, battalions being tasked to fight as pure rather than combined arms units. The briefing officer assured the participants that these assumptions would not affect the quality of the data being collected. He then thanked the participants for their cooperation and left the laboratory.

After the briefing, the participants were divided into two-man teams, each team was assigned at random to one of the two experimenters who collected data, and the teams and experimenters got settled in their respective data collection rooms. The experimenter explained briefly the participants' role in the experiment and then asked them to fill out a background information form. Using data from the completed forms, he assigned one participant as S1-G1 and the other as S4-G4. He then informed the participants that as a team, they would be asked to solve eight sets of problems, with 10 problems in each set. Data would be collected in two phases, with a total of 40 problems in each phase.

Training the participants. Each participant then read a copy of the sample problem solving situation. After they finished, the experimenter showed them the information sources they'd be using for problem solving. The charts prepared for the manual method were sufficiently familiar to the participants that they required little explanation. Acting on the advice of subject matter experts, the experimenter told participants using the manual method that they would not be allowed to use electronic calculators or other mathematical aids for computations. All such computations would have to be performed using pencils and paper provided for that purpose.

Of course, the simulated computer displays prepared for the TOS method were unfamiliar to the participants and therefore required explanation. The experimenter described each display type individually while the participants looked at examples and asked questions, if necessary.

When the participants indicated that they understood their information sources, the experimenter gave participants in the manual method a personnel and weapon system attrition worksheet, a copy of the portion of FM 101-10-1 dealing with division-level personnel attrition prediction, and a copy of a procedure for predicting weapon system attrition for the M60A2. He then gave each participant a set of eight practice problems, containing two problems from each combination of the two problem types and two problem categories described earlier. The experimenter watched the participants closely to ensure that they followed procedures properly in order to obtain correct solutions. As necessary, he provided explanations and clarifications, encouraging the participants to ask questions about anything that was not clear.

Data collection. As soon as the participants indicated their readiness to proceed, the experimenter handed each of them a copy of the first phase of one of the problem solving situations described earlier. After both participants had read the description of their problem solving situation, the experimenter handed each participant a list of 10 problems. He then started an electronic stopwatch. The experimenter's subsequent activities depended on the method being used. In the TOS method, he played the role of "computer." He had manila folders in his possession, containing all the simulated computer displays. He located the display requested by the participant for a given problem and handed it to him. Then, when the participant finished with the display, the experimenter returned it to the folder. In the manual method, the experimenter located requested information in his supplemental data bases, wrote it on the participant's note, marked the number of the problem set on the note, and returned it to the participant. When not busy with responses to such requests, the experimenter sat quietly and observed the participants.

In both methods, the experimenter politely refused to tell participants whether their solutions were correct or incorrect, or to compare the team's performance with that of other teams. He answered specific questions about experimental procedures, or about information provided on displays, but he did not volunteer information when he observed participants doing something incorrectly.

As soon as the participants indicated that they had finished the first set of 10 problems, the experimenter stopped the electronic stopwatch, collected the problem set, and recorded the problem solution time to the nearest second. He then handed each participant the second set of problems. The procedure for this and the next two sets of problems was the same as for the first set. After the participants finished the fourth set, the experimenter provided a ten-minute break. He then gave them the second phase of the written description of the problem solving situation. When the participants finished reading it, they were given the same four sets of problems as in the first phase, according to the same procedure.

Data collection ended either when the participants had solved a total of 80 problems, or when time ran out on the four-hour period allotted for the experiment by the CGSC. The experimenter then asked the participants for any comments, criticisms, or suggestions they might have and recorded their responses, if any. Finally, he thanked the participants for their cooperation and escorted them out of the data collection room.

Data analysis. The plan for the comparison of the TOS and manual methods called for six dependent measures: (1) time required by a team to solve a set of 10 problems; (2) number of errors of omission in solutions to a set of 10 problems; (3) number of errors of commission in solutions to a set of 10 problems; (4) rating of the value of a problem solution in the performance of the S1-G1 or S4-G4 function, averaged over a set of 10 problems; (5) rating of the value of a problem solution compared to the effort required to obtain that solution, averaged over a set of 10 problems; and (6) number of requests for additional or clarifying information. However, data were analyzed for only four dependent measures.

No team made an error of omission. For this reason, measures of errors of commission and omission were replaced by the number of correct solutions per set of 10 problems. Also, no team using the TOS method for solving problems ever requested additional or clarifying information. Further, teams using the manual method requested such information a total of 44 times while solving "conventional" types of problems, and 136 times while solving "TOS" types of problems. No statistical analysis is necessary to show that teams using the manual method needed more help than those using the TOS method, or that such teams needed help more often when solving the "TOS" problems than when solving the "conventional" problems.

Data were tabulated for each two-man team rather than by individual participant. First, the participants themselves decided who solved each problem. Second, the performance of the team was the central issue of this experiment, rather than that of individual participants. The reason for this focus lies in the systems concept. Since weapon systems include personnel as well as equipment, S1-G1 and S4-G4 personnel will have to work together on weapon system problems if the applications described in this report are to succeed.

The experimental design shown in Table 4 required each two-man team to solve a total of 80 problems. The first 40 of these problems (i.e., four sets of 10 problems each) were solved in the context of the first phase of the problem solving situation, a defensive operation in Situation One, and an attack operation in Situation Two. Pilot tests had suggested that teams using either the manual or the TOS method could complete both groups of 40 problems in the time allotted. During the experiment itself, this proved not to be the case.

Each of the 10 teams using the TOS method for problem solving completed all 80 problems. By contrast, only two of the 10 teams that used the manual method completed 80 problems. One such team solved 70 problems, and one solved 60. The remaining six teams solved 40 problems. Thus, the data matrix of Table 4 was partially incomplete. The "Attack" cells under Situation One and the "Defense" cells under Situation Two are the affected cells. Obviously, data could not be analyzed with the analysis of variance model implied by Table 4.

Table 5 shows a revised experimental design to analyze two-thirds of the data actually obtained, that is, data from the first 40 problems. Note that the design permits comparison of the manual and TOS problem solving methods, the most important purpose of the experiment. Further, it permits this comparison over both the status and prediction problem categories, and over both offensive and defensive operations. Thus, the only variable actually lost is that of complete problem solving situations, in which the effects of attack and defense are counterbalanced.

TABLE 5

REVISED EXPERIMENTAL DESIGN TO COMPARE THE TOS METHOD WITH THE MANUAL METHOD USING DATA FROM THE FIRST 40 PROBLEMS.

		Manaul Method		TOS Method	
		Attack T_1-T_5	Defense T_6-T_{10}	Attack T_{11}-T_{15}	Defense T_{16}-T_{20}
Stat	"CONV"				
	TOS				
Pred	"CONV"				
	TOS				

The design and analysis model described immediately above ignores one-third of the available data, those obtained for the second group of 40 problems solved by teams using the TOS method. Another design can be used to analyze this data, though it requires a second use of data for the first group of 40 problems solved by the same teams. The design is shown in Table 6. Of course, using even part of one's data twice violates a cardinal statistical rule, and increases the probability of a Type I error. However, if this possibility is kept firmly in mind, and if appropriate caution is observed in interpreting the results, the second design (Table 6) permits full use of the available data.

Analyses of variance based on these models are presented in Appendix E.

TABLE 6

REVISED EXPERIMENTAL DESIGN TO EXAMINE DATA COLLECTED FROM THE TOS METHOD FOR EFFECTS OF PROBLEM SOLVING SITUATIONS AND OTHER VARIABLES.

			Prob. Sit. 1	Prob. Sit. 2
Attack	Stat	"CONV"		
		TOS		
	Pred	"CONV"		
		TOS		
Defense	Stat	"CONV"		
		TOS		
	Pred	"CONV"		
		TOS		

RESULTS AND DISCUSSION

Data Comparing the TOS and Manual Methods

Problem solution times. The analysis of variance for the first group of 40 problems reveals a significant main effect of methods ($p < .001$) and a significant interaction of methods with problem categories ($p < .025$). Teams using the manual method required an average of 24.1 minutes to solve a set of 10 problems, compared with an average of 6.3 for teams using the TOS method. Figure 2 shows that teams using the manual method took just under 50 percent more time to solve a set of prediction problems than they did a set of status problems. By contrast, teams using the TOS method solved sets of problems in the prediction category more than four times as fast as those in the status category.

The fact that teams using the TOS method were able to solve problems almost four times as fast as those using the manual method supports the view that the application recommended earlier in this report facilitates problem solving performance. That is, teams using the manual method frequently had to compute quantitative values which teams using the TOS method could obtain merely by

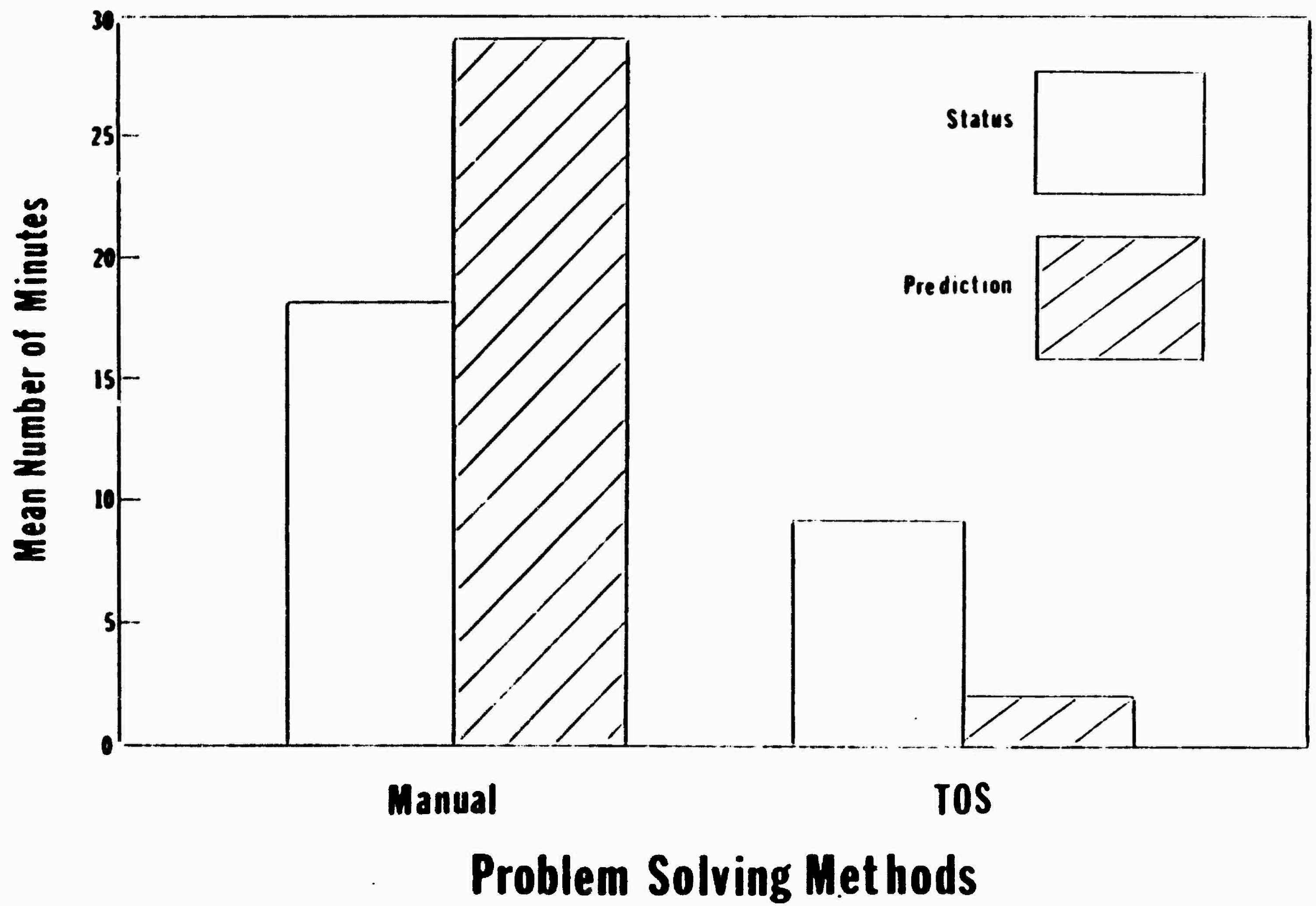

Figure 2. The interaction of problem solving methods with problem categories for the mean number of minutes required to solve a set of 10 problems (data from the first 40 problems).

calling for an appropriate display that had been generated in accordance with the concept of the application. One might be tempted to argue that this finding results from the fact that teams using the manual method were not permitted to use calculators. Certainly, requiring calculations to be performed by paper and pencil extended the time required by these teams to solve problems. Even so, permitting the teams to use calculators would surely not have reduced the time sufficiently to eliminate the significant main effect. After all, one can still extract information from a display faster than he can operate a calculator.

More importantly, problem solution times for teams using the manual method were extended by the necessity for these teams to use a complex procedure for many of their problems. The interaction of problem solving methods with problem categories (Figure 2) illustrates this fact. Teams using the TOS method solved status problems more than twice as fast as those using the manual method. Though status problems did not require much computation in the manual method, they did require frequent requests for additional information and then analysis or synthesis of that information. Meanwhile, in the TOS method, team members could locate status information merely by studying the appropriate displays.

Indeed, the fact that teams using the TOS method required an average of 8.8 minutes to solve a set of status problems may indicate a need to improve the designs of the status displays used for the experiment.

However, the real importance of this interaction is in the mean values for the prediction category: teams using the TOS method solved sets of prediction problems more than 15 times as fast as those using the manual method. The only displays given teams in the manual method were two tables of attrition coefficients from FM 101-10-1 and a typewritten procedure for calculating weapon system attrition predictions. This procedure required sequential calculations. During training sessions, the experimenters urged participants to study the procedure carefully, to use it with practice problems, and to ask questions about it until they were satisfied they were familiar with it and could use it properly. When participants worked practice problems, the experimenter watched closely and provided immediate feedback. Nonetheless, during the actual data collection sessions, experimenters observed participants repeatedly returning to study the procedure and engaging in discussions with their partners about its use. Both experimenters agreed that time spent in these studies and discussions was far more extensive than time spent in paper and pencil computations.

In the TOS method, by contrast, a team member had merely to glance at a display to find his problem solution. The recommended application, then, relieved team members of the burden of a sequential procedure and extensive computations.

One might argue that the training and practice given in the use of the manual attrition prediction procedure was inadequate. This argument certainly has merit, because the participants were available for only four hours for both training and data collection. One might also argue that the procedure could have been better written for clarity of understanding and that the worksheet could have had a better layout. Such criticisms, of course, can be offered in regard to any job performance aids. Nonetheless, even with overlearning, the use of calculators, and a faultless procedure and worksheet, one can still argue that teams using the TOS method would have solved prediction problems faster than those using the manual method. The important difference remains the speed of locating numerical data on a display compared to the speed of performing numerical calculations.

There is another issue to be considered here. An individual seeking information from a TOS computer in a real situation would have to sit down at a computer terminal and execute a sequence of keying operations to tell the computer what information he needed. Certainly, this would take more time and probably induce more errors than merely asking the experimenter in a laboratory for a simulated display. And of course, the computer might be "down," although one naturally hopes and expects that this would be a rare event. Even so, compare these characteristics of the real TOS method with the characteristics of the manual method. Currently, information needed to solve many of the problems used in this experiment is not immediately available to S1-G1 and S4-G4 personnel. To obtain the information, the officer must either physically visit the location of the appropriate source, or more often, contact the source by telephone or radio. Interviews with two FORSCOM divisions suggest that this procedure can consume hours rather than minutes. In view of these considerations, the experiment was clearly biased in favor of the manual method, where a team member had merely to write a note to a person in the same room to obtain his required information. That the application underlying the TOS method still emerged the "winner" is even more impressive in light of these facts.

<u>Number of correct solutions.</u> The analysis of variance for total numbers of correct solutions per set of 10 problems in the first group of 40 problems reveals a significant main effect of methods ($p<.005$), and significant interactions of methods with problem categories ($p<.025$) and of problem solving situations with problem categories ($p<.025$). Teams that used the TOS method achieved a mean of 7.9 correct solutions per set of problems. By contrast, teams that used the manual method achieved a mean of only 5.6 correct solutions. Figure 3 shows a reversal of the differences between the status and prediction categories in the two methods. In the manual method, the mean number of correct solutions was greater for status than for prediction problems. Meanwhile, in the TOS method, the opposite result occurred. Figure 4 shows that teams solving problems in the context of problem solving Situation One (which involved a defensive operation for the first group of 40 problems) solved a greater number of prediction problems correctly on the average than they did status problems.

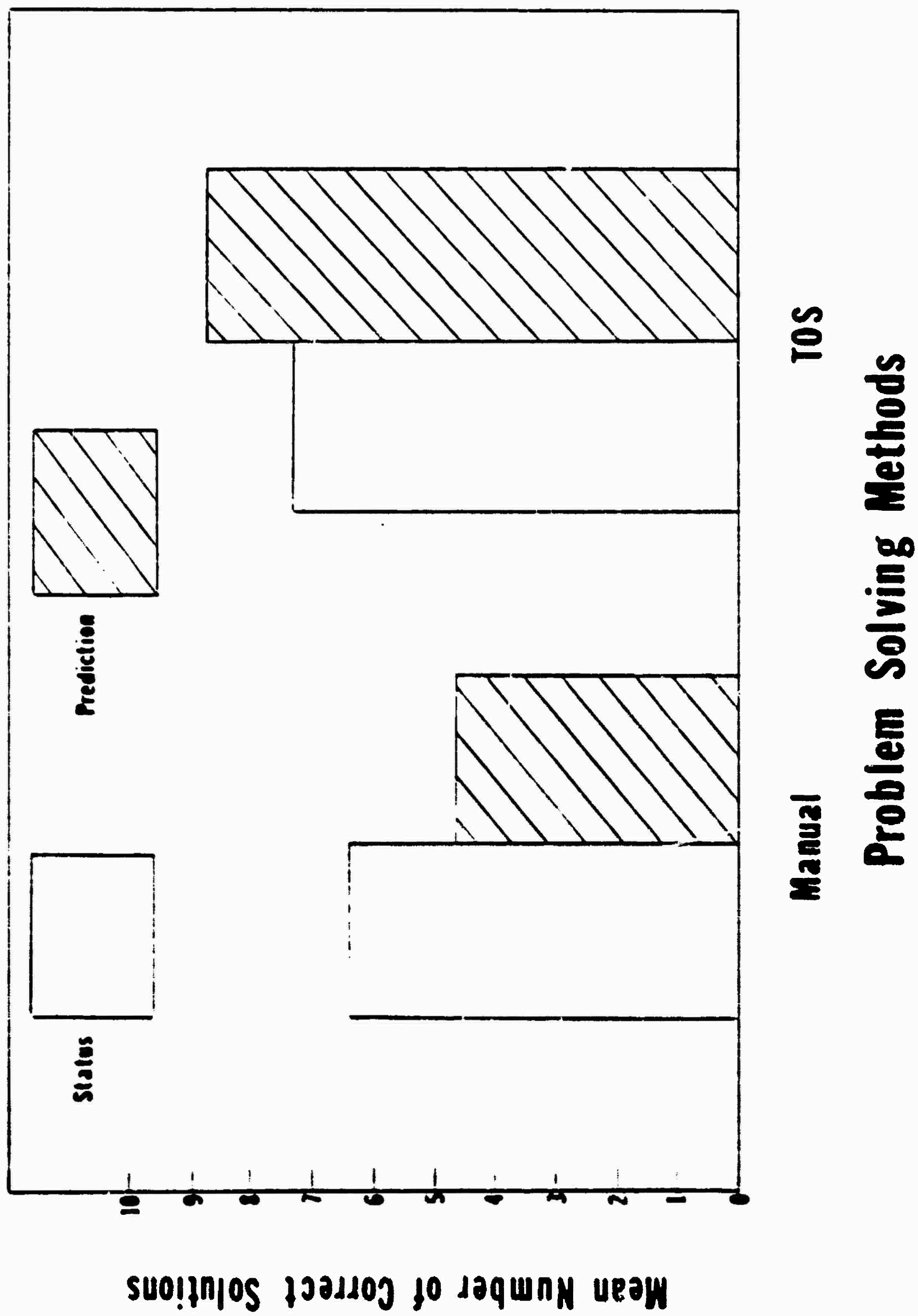

Figure 3. The interaction of problem solving methods with problem categories for the mean number of correct solutions to a set of 10 problems (data from the first 40 problems).

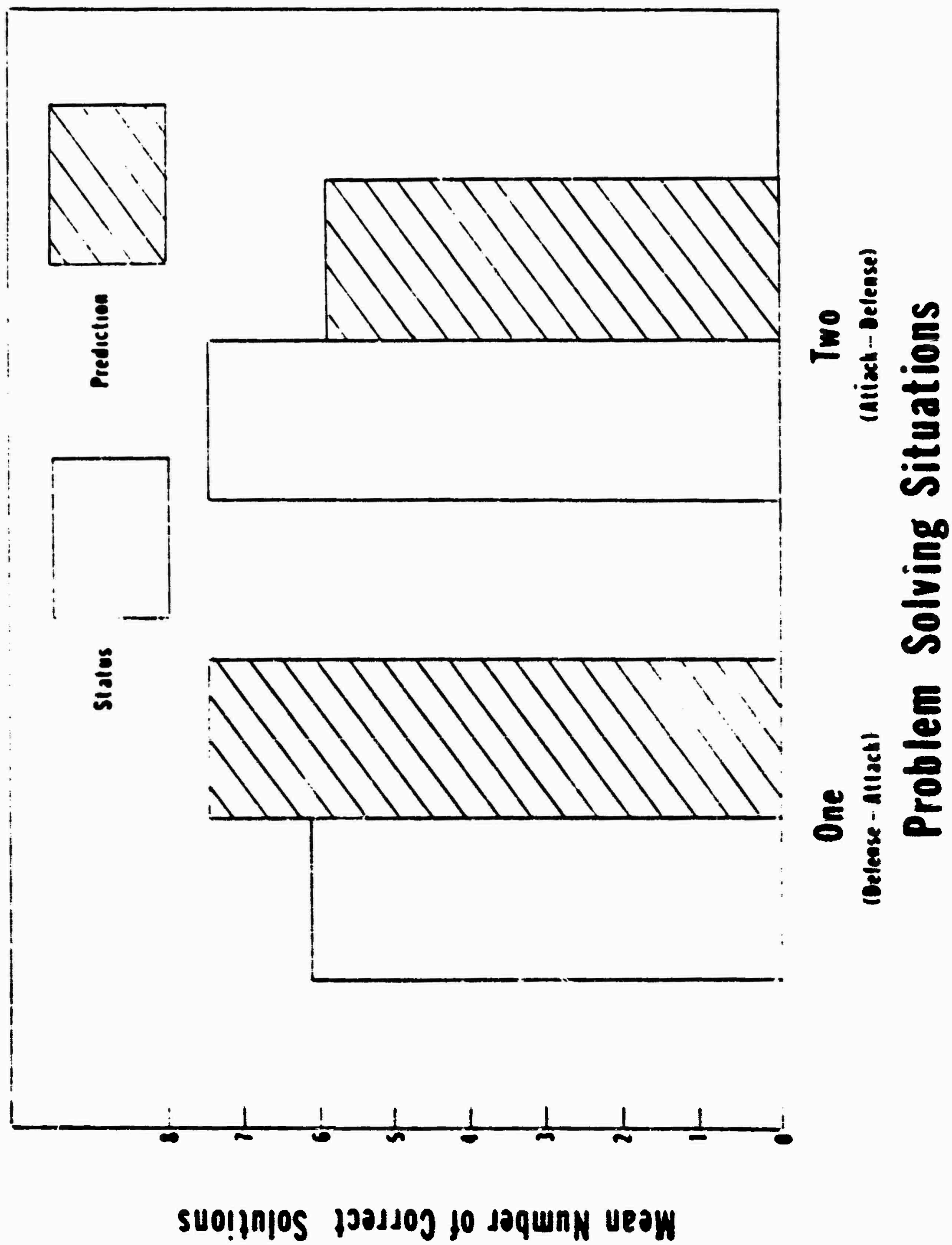

Figure 4. The interaction of problem solving situations with problem categories for the mean number of correct solutions to a set of 10 problems (data from the first 40 problems).

On the other hand, teams that solved problems in the context of Situation Two (involving an attack operation for the first problem group) solved a greater number of status problems on the average.

Once again, the fact that teams using the TOS method yielded better performance than did those using the manual method supports the recommended application. However, the fact that the teams using the TOS method averaged only about 8 correct solutions per set of 10 problems is disappointing. Here again is a suggestion that the designs of the displays used for the experiment may need improvement. This suggestion is reinforced by the interaction of problem solving methods with problem categories (Figure 3). Note that in the TOS method, accuracy was lower for status problems than for prediction problems. The figure also shows that, in the manual method, while accuracy is lower for both status and prediction categories, it is lowest for prediction. This finding confirms three observations made by the experiementers during data collection. First, some participants showed a tendency to use the procedure incorrectly, using the wrong attrition coefficients from the tables provided and/or overlooking a step in the procedure. Secondly, some participants showed a tendency to make arithmetic errors. And finally, some participants simply guessed. Indeed, one participant, confronted with a set of 10 prediction problems, glanced at the experimenter and said, "I'm gonna (sic) handle these the same way I did when my commander asked for attrition figures. I'm gonna (sic) make a WAG." Indeed, a strong argument for automating the attrition prediction procedure was the complaint voiced by most participants that it is a lengthy, exacting, and dull procedure.

The interaction of problem solving situations with problem categories (Figure 4) is intriguing. Recall that teams working under Situation One had the context of an impending defense against enemy attack, and that they solved prediction problems more accurately than they did status problems. Meanwhile, teams working under Situation Two within the context of an impending attack on enemy positions, solved status problems more accurately than they did prediction problems. Further, the two mean values for Situation Two are almost mirror images in the figures of the two means for Situation One. There is nothing in the experimental conditions or in the two experimenters' informal observations to explain this finding. Moreover, nothing in the literature suggests an explanation. Possibly, there was something in the participants' military training or experience that would provide an explanation. When several Army officers were queried about this possibility, however, they professed to be mystified. Certainly, soldiers confronting an attacking enemy have a different mental set than those who are themselves attacking. But the officers, some of whom have had combat experience, could think of nothing that would explain a result such as this one. Of course, a final possibility is that the interation is a rare Type I error. However, this interpretation is no more satisfying than any other.

Rating of the values of problem solutions. For each of the problems that he solved, each member of a team rated the value of the problem's solution to the performance of his task as either an admin or log officer. Table 7 shows the intraclass correlations (mean reliabilities) of these ratings for each set of 10 problems solved under the various combinations of experimental conditions. In general, a high positive value suggests consistent agreement among raters, and a low negative value suggests consistent disagreement among raters. Inspection of the table reveals no consistent pattern of reliability coefficients. For any given independent variable, both negative and positive (and even zero) values appear. Further, two of the values are lower than the -1.00 that is the theoretical lower limit on the value of a correlation coefficient.

The reason for these two values emerges from a consideration of the variance procedure for calculating intraclass correlations. According to Guilford[5] and others, the intraclass correlation coefficient (i.e., the mean reliability coefficient for a group of raters) is equal to the difference of the variance between items (Vp) and the error variance (Ve), divided by the variance between items (Vp):

$$\bar{r} = \frac{Vp - Ve}{Vp}$$

If the value of Vp greatly exceeds the value of Ve, then the value of the numerator is only slightly lower than the value of the denominator, and the value of $\bar{r}$, the mean reliability coefficient, will be close to +1.00. However, if the value of Ve greatly exceeds the value of Vp, then first the numerator will have a negative value, and second the absolute value of the numerator will be larger than that of the denominator. In that case, the value of $\bar{r}$ will be less than -1.00. This is precisely what happened in the two cases reported above.

This issue is cause for concern only in one respect. Rater reliability was not a major, or even a minor, concern of this experiment. However, it does have an impact on the analysis of variance of rating data. If raters tend to agree with each other, then within cell variability will tend to be low and error terms will tend consequently to be low also. However, if raters tend not to agree, then within cell variability will tend to be high and error terms will tend consequently to be high as well. While low reliabilities do not invalidate the analysis of variance test, the result will be a conservative test, which may fail to reveal effects that actually exist. Evidently, this is what happened in the rating data reported here.

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5. Guilford, J. P. Psychometric Methods (2nd Ed.). New York: McGraw-Hill, 1954. 395-397.

TABLE 7. INTRACLASS CORRELATIONS (MEAN RELIABILITIES) OF THE RATINGS OF THE VALUES OF PROBLEM SOLUTIONS GIVEN BY THE FIVE TEAMS THAT SOLVED PROBLEMS IN EACH COMBINATION OF EXPERIMENTAL CONDITIONS.

Kind Of Operation	Prob. Category	Prob. Type	Manual Method Prob. Sit. 1	Manual Method Prob. Sit. 2	TOS Method Prob. Sit. 1	TOS Method Prob. Sit. 2
Defense	Status	"CONV"	0.21	*	0.54	0.33
		"TOS"	0.50	*	-0.69	0.45
	Prediction	"CONV"	0.32	*	-0.98	0.29
		"TOS"	-2.90	*	0.00	-0.75
Attack	Status	"CONV"	*	0.58	0.45	-0.09
		"TOS"	*	0.14	-0.54	0.17
	Prediction	"CONV"	*	0.10	0.00	-2.88
		"TOS"	*	0.67	0.00	-0.16

*Insufficient data for valid analysis.

The analysis of variance of these rating data reveals a significant main effect of methods ($p<.01$) and a significant interaction of problem solving situations and problem types ($p<.05$). Teams that used the manual method gave problem solutions an average value rating of 3.8. On the other hand, teams that used the TOS method gave the same problem solutions a value rating of 4.6. Figure 5 shows that "conventional" and "TOS" types of problem sets differed little in the value ratings they received, regardless of problem solving situation. For Situation One, the difference was only 0.3 and for Situation Two, the difference of 0.15 is smaller yet.

Despite the low rater reliabilities and consequently larger error terms, the main effect of methods was significant, as reported above. Teams using the TOS method gave problem solutions higher value ratings than teams using the manual method. This finding contradicts Festinger's cognitive dissonance theory (1957)[6]. That theory would predict that people tend to attach greater importance to items for which they work harder than to those they obtain more easily. Certainly, teams using the manual method experienced greater difficulty obtaining problem solutions than did those using the TOS method. Thus, one might have expected the manual teams to assign higher ratings to problem solutions than did TOS teams. Of course, precisely the opposite occurred.

Just why this finding occurred is not clear. Possibly, the novelty of working with "computer displays," even though participants knew explicitly that they were simulations, influenced ratings by the TOS teams. In the same vein, the considerable difficulty of solving many of the problems with the manual method may have influenced the ratings by teams who used that method. However, this interpretation is speculative, since nothing in the experimental conditions suggests a ready explanation.

The significant interaction of problem solving situations with problem types (Figure 5) is scarcely worth discussing. The extremely small differences between problem types, only 0.45, in each of the problem solving situations, while statistically significant, can hardly have any practical significance.

Ratings of problem solution values relative to effort required. Table 8 shows the mean reliabilities of the ratings of problem solution values compared with the effort required to obtain them. As with the ratings described above, these data show no clear pattern, and have both negative and positive values, including one with a value less than -1.00.

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6. Festinger, L. A Theory of Cognitive Dissonance. Stanford: Stanford University Press, 1957.

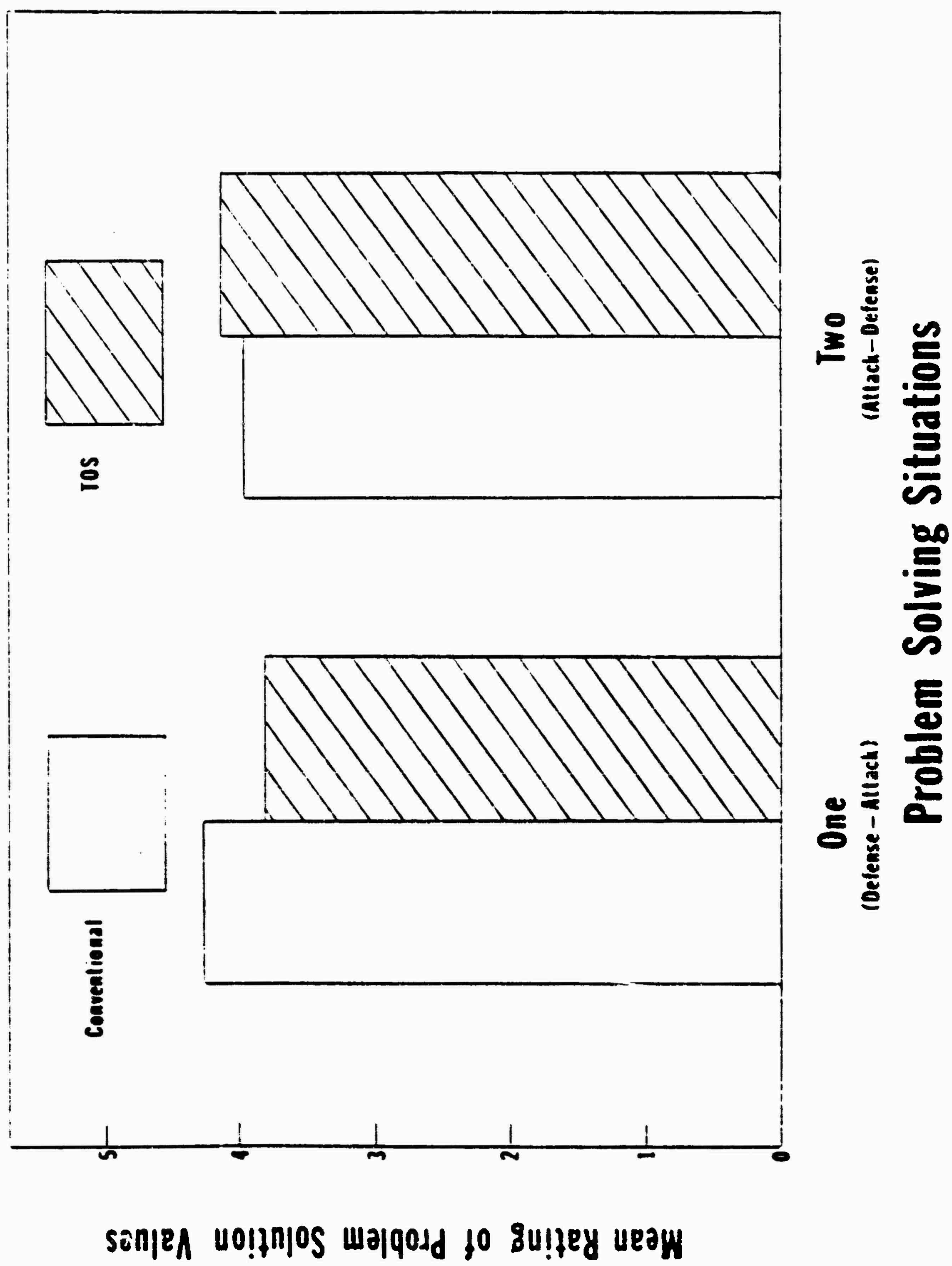

Figure 5. The interaction of problem solving situations with problem types for the mean of the ratings of problem solution values for a set of 10 problems (data from the first 40 problems).

TABLE 8. INTRACLASS CORRELATIONS (MEAN RELIABILITIES) OF THE RATINGS, GIVEN BY THE FIVE TEAMS THAT SOLVED PROBLEMS IN EACH COMBINATION OF EXPERIMENTAL CONDITIONS, OF THE VALUES OF PROBLEM SOLUTIONS COMPARED WITH THE EFFORT REQUIRED TO OBTAIN THOSE SOLUTIONS.

Kind of Operation	Prob. Category	Prob. Type	Manual Method		TOS Method	
			Prob. Sit. 1	Prob. Sit. 2	Prob. Sit. 1	Prob. Sit. 2
Defense	Status	"CONV"	-0.41	*	0.45	0.26
		"TOS"	0.19	*	0.16	0.78
	Prediction	"CONV"	0.04	*	0.00	0.29
		"TOS"	-0.92	*	-0.62	-2.50
Attack	Status	"CONV"	*	0.46	0.37	0.26
		"TOS"	*	-0.07	-0.22	-0.09
	Prediction	"CONV"	*	0.00	0.51	0.48
		"TOS"	*	0.37	-0.07	0.04

*Insufficient data for valid analysis.

The analysis of variance of data for ratings of problem solution values relative to effort required for the first group of 40 problems shows a significant main effect of methods ($p<.01$). On the average, teams using the manual method rated a set of problem solution values compared to the effort required to obtain them at 3.7. The corresponding value from teams using the TOS method was 4.4.

This finding is more predictable than the corresponding result for the problem solution value ratings. Even status problems, which were less easy to solve with the TOS method than prediction problems, nevertheless were still relatively easy to solve when compared to the difficulty of solving them using the manual method. Therefore, one might expect that problem solutions having relatively low values would be rated more highly than the effort required to obtain them more often by TOS teams than by manual teams. Apparently, this is in fact what happened.

Summary of analyses of data for the comparison of TOS versus manual methods. Relieved of the necessity to compile information, follow detailed step-by-step procedures, and calculate numerical quantities, teams using the TOS method were able to solve problems faster and more accurately than teams who were not relieved of these tasks. The TOS teams generally rated problem solutions as having greater value in the performance of S1-G1 and S4-G4 duties than did the manual teams. Moreover, the TOS teams rated problem solution values compared to effort required to obtain those solutions higher than did the manual teams. Interactions in the anlyses of both problem solution times and numbers of correct solutions suggested that the simulated computer displays used in the TOS method needed improvement, particularly in the case of status displays.

Data From the TOS Method Examined Alone

Recall that analyses of data from all eight sets of problems solved with the TOS method used some of the data analyzed previously. Therefore, results reported for these analyses and discussed below must be viewed with caution.

Problem solution times. The analysis of variance of problem solution times for all eight sets of problems solved with the TOS method shows four significant effects. Differences were significant for groups of 40 problems ($p<.025$), for problem types ($p<.025$), and for problem categories ($p<.001$), and the interaction of problem types with problem categories was also significant ($p<.025$). Whereas teams using the TOS method solved a set of 10 problems in an average of 6.3 minutes during the first half of the experiment (first 40 problems), they required only 4.2 minutes per set during the second half (last 40 problems). Further, they averaged 4.5 minutes to solve a set of "conventional" problems, when the data are pooled for all four such sets, compared with an average of 6.0 minutes per set of "TOS" problems across the four sets of that type. Also, they solved a set of status problems in a mean of 8.0 minutes, while taking a mean of only 2.9 minutes for a set of prediction problems.

Figure 6 shows the interaction of problem types with problem categories. Sets of status problems required more time on the average than did sets of prediction problems, regardless of problem type. However, the difference between the status and prediction categories is much greater for the "TOS" type of problem than for the "conventional" type. Notice too that the mean value for the "TOS" status problem sets is greater than that for the "conventional" status problems, while the mean for the "conventional" prediction problems is only about a minute greater than that for the "TOS" prediction problems.

Teams solved problems faster in the second half of the experiment than they did during the first half. Thus, the data suggest that some learning occurred during the course of data collection. The fact that teams using the TOS method solved "conventional" problems more rapidly than "TOS" problems is neither particularly interesting nor especially important. Recall that "conventional" problems are those which should be solved with relative ease using the limited displays that are available today or using the attrition prediction procedure described in FM 101-10-1. By contrast, "TOS" problems are those that are difficult to solve with current displays and procedures. Of course, SDC's recommended TOS application is designed to facilitate solving both types of problems. The difference in problem solution times may be attributable in part to differences in familiarity of the team members with "conventional" as opposed to "TOS" types of problems. More importantly some "TOS" questions were probably more difficult inherently. For example, while a "conventional" problem might require the team to determine the number of M60A2 tanks available, a "TOS" problem might require the team to determine the greatest shortage of M60A2 components. The "conventional" problem is solved merely by locating a numerical value on a display, but the "TOS" problem is solved only after comparing the numbers of components available for the equipment and for each of four crew positions.

The difference between problem solution times for status and prediction problems is explained in the same vein. Status displays used in this experiment contained greater amounts of information than did prediction displays. Further, as suggested earlier, they may not have been human engineered as well as prediction displays. Thus, team members could not locate information as quickly on status displays as they could on prediction displays.

The interaction of problem categories with problem types amplifies the above discussion of the two main effects. Note that teams solved sets of "conventional" status problems in much less time than they needed to solve sets of "TOS" status problems. The example used for the discussion of problem types above, of course, was a status problem, and it serves to explain this part of the interaction. Prediction displays for personnel attrition ("conventional" prediction) and weapon system attrition ("TOS" prediction) were very similar in format and appearance. Thus, one would expect roughly equal problem solution times. The figure shows that "TOS" prediction problems were solved more quickly, but the difference is only just over a minute.

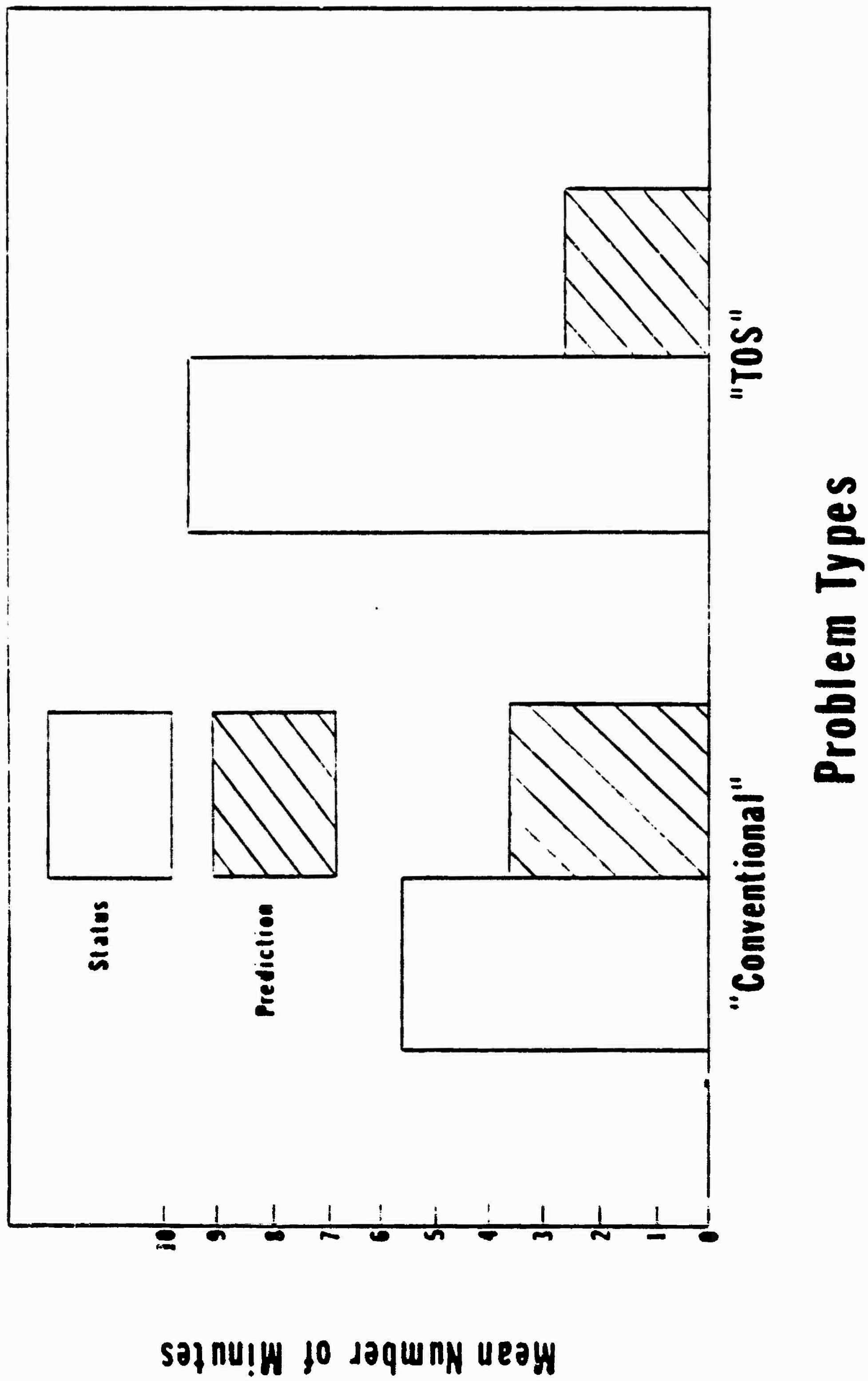

Figure 6. The interaction of problem types with problem categories for the mean number of minutes required to solve a set of 10 problems (data from the TOS method only).

Number of correct solutions. The analysis of variance for the number of correct solutions for all eight sets of problems solved with the TOS method shows significant main effects of problem types ($p<.05$) and problem categories ($p<.005$), and significant interactions of problem types with problem categories ($p<.05$), and problem solving situations with problem groups and problem categories ($p<.05$). Teams using the TOS method scored a mean of 7.5 correct solutions per set of "conventional" problems, compared to a mean of 8.4 per set of "TOS" problems. They averaged 7.1 correct solutions per set of status problems, and 8.8 correct solutions per set of prediction problems. The interaction of problem types with problem categories appears in Figure 7. For both types of problems, teams obtained fewer correct solutions per set of status problems than per set of prediction problems, on the average. However, the mean number of correct solutions per set is about equal for status problems of both types, while the mean number of correct solutions for prediction problems is greater for the "TOS" type than for the "conventional" problem type. Figure 8 shows the interaction of problem solving situations with problem groups and problem categories. The mean values for status problems are about equal for both groups of 40 problems in Situation One, and again in Situation Two. However, the two mean values for status problems in Situation Two are higher than those in Situation One. By contrast, the mean value for prediction problems present quite a different appearance. First, the mean values are higher in Situation One than in Situation Two. Second, the mean values are higher for the second group of 40 problems than for the first group.

Although they averaged more time on a set of "conventional" problems, teams using the TOS method solved more "TOS" problems correctly than they did "conventional" problems. However, the difference in means is only 0.9; even though this difference is statistically significant, it appears to have little practical significance. The difference in numbers of correct solutions to the status and prediction problems is consistent with results reported earlier.

The interaction of problem types with problem categories amplifies the above discussion. In both "conventional" and "TOS" types, teams solved more prediction problems correctly than they did status problems. In the "conventional" type, however, the difference between status and prediction is smaller than in the "TOS" type, primarily because teams obtained a greater number of correct solutions to "TOS" prediction problems than to any other combination of types and categories of problems. The explanation for this finding lies in an observation made by both experimenters. Some of the "conventional" prediction problems required the team to determine the predicted number of battle losses while others required them to determine the predicted total number of (i.e., sum of battle and non-battle) losses. Teams were observed frequently to give the total number of losses when the problem required the number of battle losses. As it happened, "TOS" prediction problems all required only total numbers of losses.

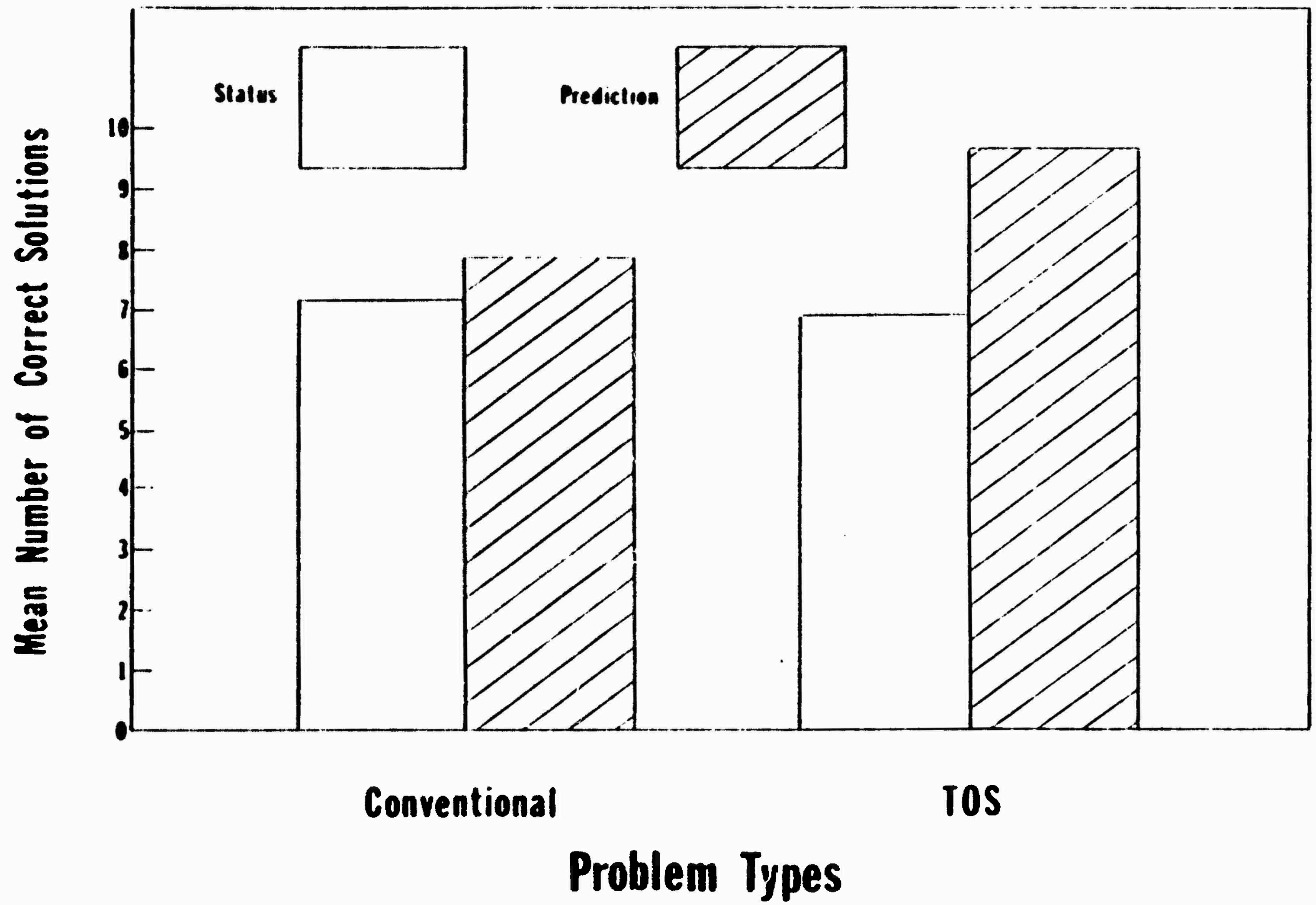

Figure 7. The interaction of problem types with problem categories for the mean number of correct solutions to a set of 10 problems (data from the TOS method only).

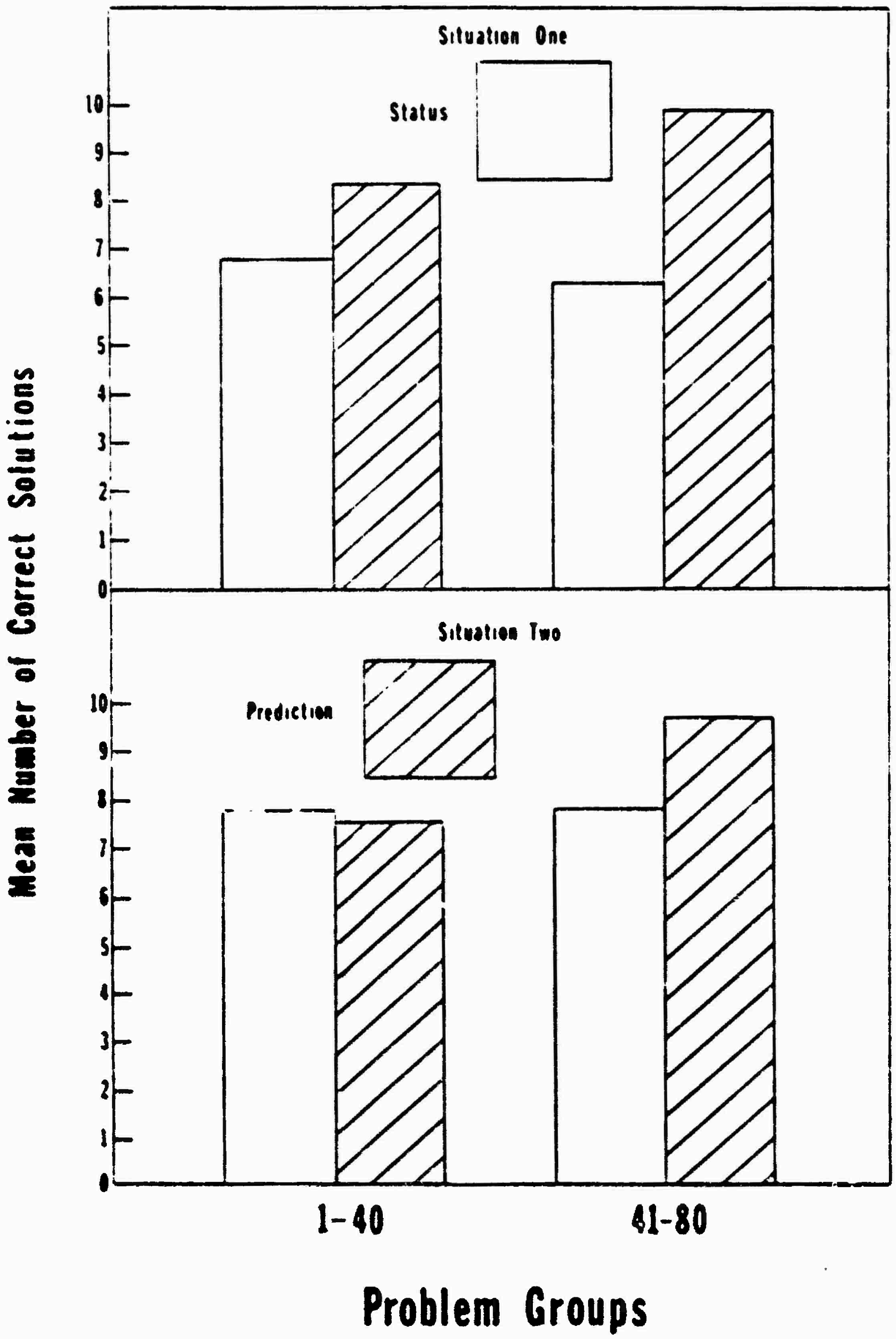

Figure 8. The interaction of problem solving situations, problem groups, and problem categories for the mean number of correct solutions to a set of 10 problems (data from the TOS method only).

The triple interaction of problem solving situations with groups of 40 problems and problem categories is intriguing. Recall that in the earlier analysis of numbers of correct solutions, a significant double interaction emerged of problem solving situations with problem categories. No ready explanation for that interaction was apparent. Similiarly, no clear explanation is evident for the involvement of problem solving situations in this triple interaction. Notice that the two mean values for status problems are about equal to each other in Situation One, and that the corresponding values in Situation Two are also about equal to each other. These values suggest that no learning occurred in the solution of status problems. However, the figure shows that, in both problem solving situations, the correct solutions to prediction problems increased from the first to last set of problems. Considering the designs of the two kinds of displays discussed earlier and the length of time that participants were available, this portion of the interaction is not surprising.

Thus far, the interaction makes good sense and is understandable. But notice that the two mean values for status problems in Situation One (which are roughly equal to each other, remember) are lower than the two corresponding values in Situation Two (which are also roughly equal to each other). Meanwhile, mean values for prediction problems in Situation One are higher than the corresponding values in Situation Two. Granted, the differences between means for status problems and between means for prediction problems do not change greatly from Situation One to Situation Two. But look at all the means another way. In both problem groups, the difference between status and prediction problems is at least twice as great in Situation One as in Situation Two.

Once again, there seems to be no credible explanation for this aspect of the interaction.

Ratings of the values of problem solutions. The analysis of variance of value rating data for all eight sets of problems solved with the TOS method yielded one significant effect, the interaction of problem groups with problem categories ($p<.005$). Figure 9 shows small differences between the ratings given to status and prediction problems in both groups of problems (.15 in the first group versus .20 in the second), with the larger difference occurring in the second group of 40 problems.

The interaction of problem groups with problem categories in the analysis of the teams' ratings of problem solution values in probably not of great importance. Mean ratings of the values of problem solutions for both the status and prediction categories rose from the first group of 40 problems to the second, though not by much. Evidently, there was a weak tendency for perceived value to rise as participants learned to solve problems more easily. Moreover, the difference between ratings for status and prediction problem solutions increased from the first half to the second half of the experiment, because of a greater increase in ratings for prediction problem solutions. Here again, however, the difference in changes is small, indicating a weak tendency if any. Thus, while

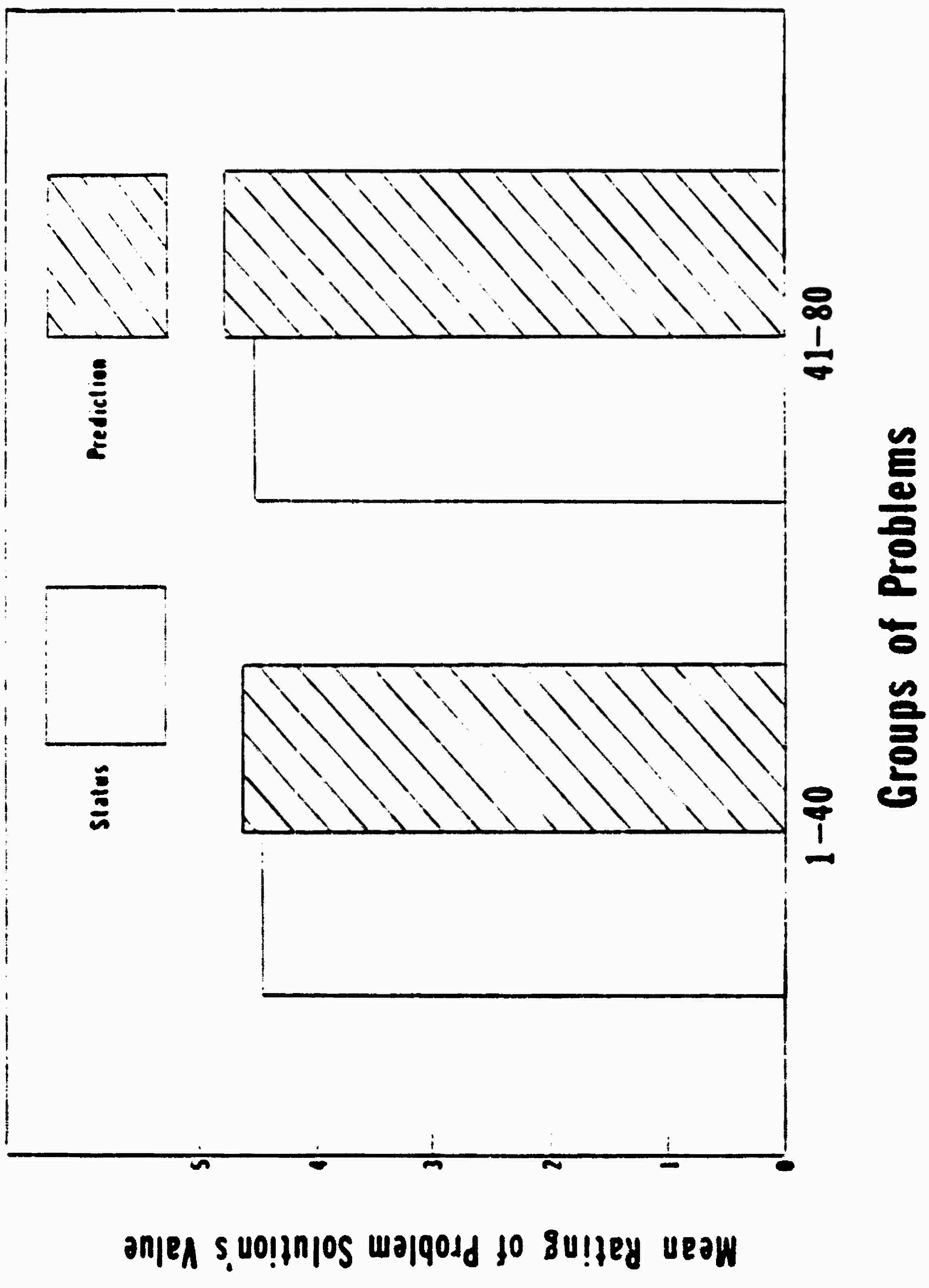

Figure 9. The interaction of proble. groups with problem categories for the means of the ratings of problem solution values for a set of 10 problems (data from the TOS method only).

changes in attitude toward problem solutions occurred with sufficient consistency to be statistically significant, those changes were so small as to have only marginal implications for TOS, if they have any at all.

Ratings of problem solution values relative to effort required. The analysis of variance of data for ratings of problem solution values relative to effort required for all eight sets of problems solved with the TOS method yielded only one significant effect: the interaction of problem groups, problem types and problem categories ($p<.05$). Figure 10 illustrates this interaction. The "TOS" type of problem shows a consistent difference between the status and prediction categories in both groups of 40 problems. That is, teams rated "TOS" prediction problem solutions more valuable relative to effort than they did "TOS" status problem solutions in both groups of problems, and the difference of 0.3 was the same in each case. The conventional type of problem yielded a different pattern of results. For the first 40 problems, teams rated "conventional" prediction problem solutions more valuable relative to effort than they did "conventional" status problems. However, for the second group of 40 problems, teams rated "conventional" status problem solutions more valuable relative to effort than they did "conventional" prediction problems. Another aspect of this interaction is that ratings rose from the first to the second group for all types and categories except the "conventional" prediction problem solutions. Ratings for these solutions decreased as much as or more than the other ratings increased.

This triple interaction also shows differences so small as to be relatively unimportant in ratings of problem solution values compared to the effort required to obtain them. Mean values for "conventional" status and for "TOS" status and prediction problem solutions all rose from the first half of the experiment to the second half, though not by much. This finding suggests a weak tendency to perceive problem solutions as having greater value compared to problem solving effort after gaining experience in the task. The exception was the mean rating for "conventional" prediction solutions, which declined over time. No explanation readily appears for this exception.

Summary of analyses of data from the TOS method. Teams using the TOS method solved problems faster in the second half of the experiment than they did in the first half. However, they were not more accurate in the second half than in the first half. Ratings of problem solution values and of the values of these solutions relative to the effort required to obtain them did not change over the course of the experiment, when the data were pooled across problem solving situations, problem types, and problem categories.

Teams solved "conventional" types of problems more quickly than they did "TOS" types, reflecting the greater difficulty of the latter types. Nonetheless, they obtained somewhat larger numbers of correct solutions to "TOS" problems than to "conventional" problems. However, the difference was so small as to be negligible for practical purposes. Ratings of problem solution values and of

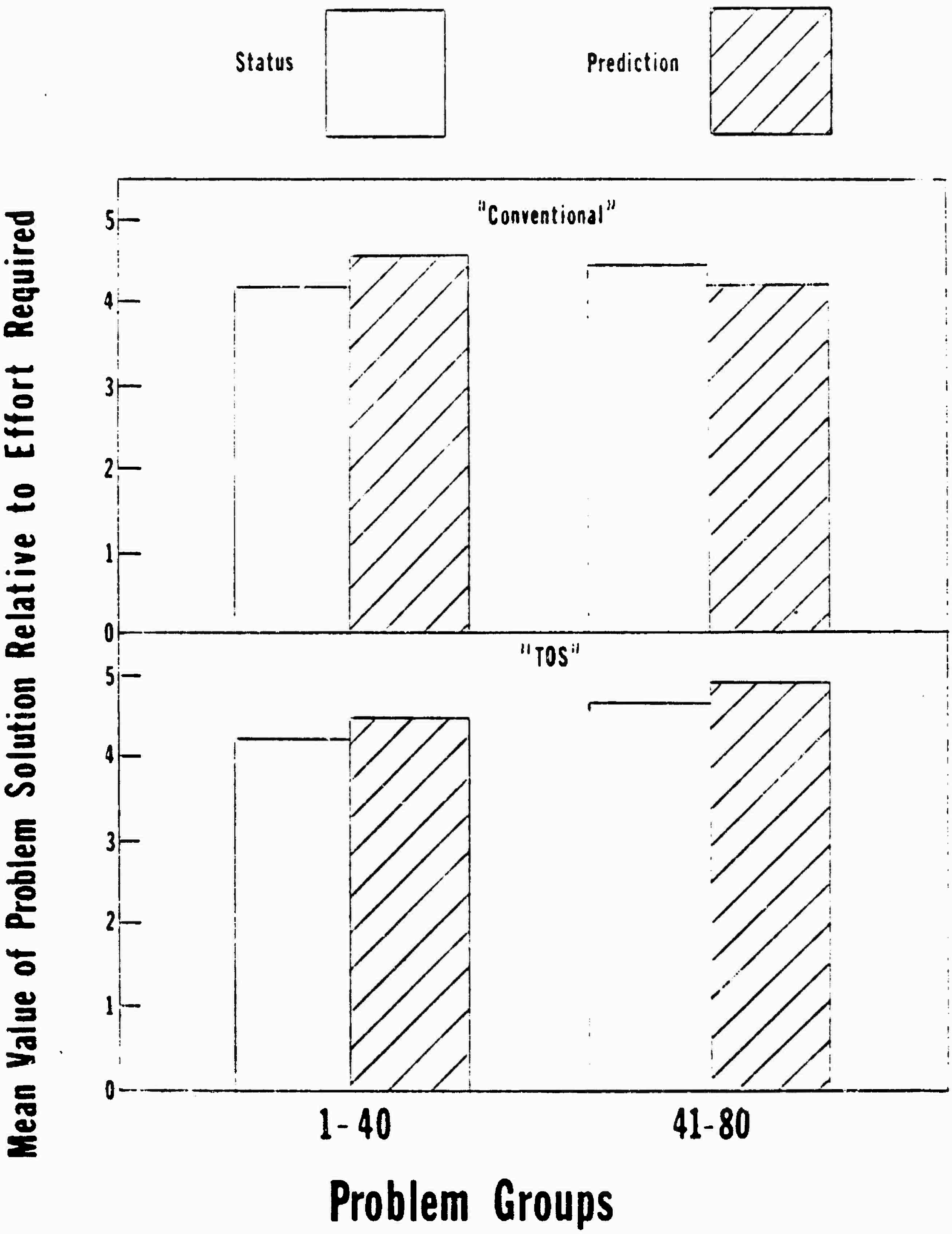

Figure 10. The interaction of problem groups, problem types, and problem categories for the means of the ratings of problem solution values compared to effort required for a set of 10 problems (data from the TOS method only).

solution values compared to effort did not differ, suggesting that teams felt both types of solutions were equally valuable.

Differences between problem solution times for status and prediction problems reinforced earlier speculation that status displays in particular need to be redesigned. Rating data yielded no differences between problem categories.

In general, interactions in the TOS data merely reinforced interpretations of the main effects. There may have been a weak tendency to regard problem solutions more valuable in regard to effort in the second half of the experiment than in the first half. Some statistically significant interactions appeared to have little or no practical significance.

CONCLUSION, RECOMMENDATION, AND IMPLICATIONS

Conclusion

The experiment demonstrated convincingly the capability of the recommended TOS software application to support personnel and weapon system status assessment. Teams using the TOS method were able to solve problems both more quickly and more accurately than could teams using a composite of current manual methods. Moreover, the TOS method enhanced problem solving performance across four different combinations of problem types and problem categories, and in the context of two different tactical operations. In addition, teams using the TOS method rated the values of problem solutions more highly than did teams using the manual method. They also rated the values of those solutions more highly when compared to the effort required to obtain them. Data for the two sets of ratings indicate that the problems used in the experiment were relevant to the performance of administration and logistics functions, and that their subjective values rose with ease of solving them. Finally, data from the TOS method alone suggested a mild learning effect, indicating that learning to use the application should not pose a major problem.

Recommendation

On the basis of needs identfied in the field survey and of results from the evaluation experiment, SDC recommends that TOS developers seriously consider implementing the application described earlier in this report. Implementation requirements and a detailed discussion of the application's organizational and system impact are provided in Appendix F. They are summarized briefly below.

Implications

Organizational impact. The application's Attrition Prediction routine would reduce greatly the time and effort currently required of personnel to prepare attrition forecasts. Further, it would extend the attrition prediction capability to major weapon systems. In so doing, it would bring the G4 into attrition prediction formally, because it predicts attrition of selected end items. At the same time, it would permit attrition prediction for selected MOSs and grades, a capability for which G1 personnel expressed a definite need. The routine's conceptual offspring, the Revised Attrition Prediction routine, would depend in its impact on its frequency of use. Even so, it would enable staff personnel to refine predictions, on the basis of battlefield rather than individual experience.

The Weapon System Status Reporting routine would enhance the timeliness and accuracy of reporting for major weapons systems. It would eliminate the need for at least some of the personnel in the current reporting chain to manipulate and transmit data. Thus, it would eliminate some of the sources of error in the data base. To obtain the greatest utility in this regard, however, data should be entered into TOS at the lowest feasible level. Additionally, an

IOD should be shared by the S1 and S4 at both the brigade and battalion trains to enhance their abilities to perform admin/log duties related to tactical command and control. The routine is designed to be compatible with the asset monitoring functions of the Weapon System Replacement Operations concept. If implemented, this concept will have considerable organizational impact because it requires joint reporting of the equipment and personnel components of major weapon systems. The routine will also provide data to validate forecasts generated by the prediction routines.

The recommended application would not require any new manual reports or any modification of existing manual reports. It would not require changes in existing manual reporting methods for admin/log data. Personnel would be required to extract data from manual reports for entry into TOS, but this would be the only addition to their current workloads.

Impact on TOS

A new permanent file would be required to store parameters required by the recommended application and to store data received or generated by it. Access to the UTO would be required for unit subordination data. However, the application routines would not store data in any file except its own new one, nor would they conflict with other TOS software. New software routines would have to be written and tested, of course.

The recommended application would increase the number of TOS users, particularly if the recommendations are accepted to allocate IODs to the brigade and battalion trains, and to provide data entry at the lowest feasible level. Input/output volume would increase, of course, as would the volume of data processing. The actual increase would depend greatly on the frequency of reporting and of use.

APPENDIX A

Potential Function Descriptions

This appendix describes briefly the 34 potential TOS software applications that were extracted from the first year's effort under this contract. Each potential application responds to a need identified during SDC's effort to develop a systems concept for the operation of a division equipped with TOS.

POTENTIAL FUNCTION DESCRIPTIONS

1. Develop Automatic Distribution Matrix Capability.

Develop a software distribution matrix to automatically distribute messages to a standard list of users without operator designation. The matrix would contain the message characteristics or combination of characteristics such as type, subject, activity, or source for each category of message having a unique distribution. Development of this process should also consider message precedence which could automatically be established using this same criteria.

2. Develop Total Division Automatic Reporting to Corps.

Corps reporting requirements for all elements, unclassified and classified, need to be examined to determine total division reporting responsibilities. Based upon the analysis, the division data base should be restructured to include all new data items to ensure that a total center-to-center reporting capability can be delivered. The area needs further study before data processing can be applied.

3. Define TAC CP Memory Storage Requirements and Processing.

This enhancement appeared in the original list of potential enhancement targets but was eliminated by SDC as being not data processing oriented. The area needs further study before data processing can be applied.

4. Develop Road Movement Analysis Routine.

No support program currently exists in TOS to aid planners in performing this task. The automatic generation of movement tables and strip maps should significantly improve the time and effort currently expended to perform this work. This enhancement should be an algorithm which could conduct a multi-file search, organize and calculate requirements specified by the user, and output the planning data in a form immediately useable by the planner.

5. Develop Enemy Troop Movement Analysis Routine.

The routine might take an incoming ESD report whose activity is one of movement and use the subject, location, movement direction, and quantity entries to conclude: the enemy unit the object belongs to, the object's relative position within the units, probable traffic points along its path (i.e., bridges and obstacles), enemy unit the object is moving to reinforce, and the friendly unit the object is moving to engage. The only apparent data not currently considered for inclusion in TOS is the doctrinal kinds of equipment and strengths for various types of enemy units that could be used to aid in determining the parent unit of the object.

6. Develop Pattern Analysis Routine to Predict Enemy Intentions.

The routine could take some limited area(s) of enemy activity (other than EOB) and use the ESD file entries concerning that activity to predict the enemy's intention. Possible activity areas might be counterintelligence, artillery movements and placements, or engineering activity.

7. Develop Order of Battle Analysis Routine.

The routine could take the EOB file current and historical records for designated enemy units and use their relative positioning through time to conclude: for each enemy unit, whether it is committed or reinforcing, unit boundaries, which designated units are attached to the same parent organization, and the most probable enemy courses of action based on order of battle.

8. Develop an Operational Planning Data Search Routine.

Operations planning personnel are required to assemble a composite picture of TOS data base items which can be used in operations order planning, contingency planning, and tactical planning. These searches now require multiple passes through the data base to assemble all required data. One multi-search routine could be developed to assemble this data and present it in a format considered useable by operations planners. This enhancement is closely allied and could be part of number 17.

9. Develop Consolidated Division Display Requirements.

This enhancement appeared in the original list of potential enhancement targets but was eliminated by SDC as being not data processing oriented. The area needs further study before data processing can be applied.

10. Develop an ECM Vulnerability Analysis Routine.

Develop a routine that could automatically assess the potential impact and/or vulnerability of friendly forces to enemy identified offensive and defensive jamming devices. The routine could automatically be initiated upon identification of a jamming device. The offensive/defensive analysis could be conducted and presented to interested users.

11. Develop G1 Information Status Staff Working File.

The G1 has need of a data base within the TOS system to support operations planning. This requirement could be satisfied through a SWF containing units, locations of units, authorized strengths, assigned strengths, casualty information, and other personnel related data useful in planning and reporting the personnel situation and recommending solutions to operations. Routines to project losses and consider gains, compare relative strengths, monitor critical MOSs, etc., are techniques that might also be useful to the G1. Such a capability is suggested in enhancement number 34.

12. Develop a Routine for Projecting Enemy Analysis of Friendly Forces.

Develop a routine to estimate what the enemy knows about us. The routine might use the ESD file entries reporting enemy intelligence collection activities, inputs concerning the location and type of enemy electromagnetic collection devices, and file data on friendly units to estimate what the enemy knows about us. For example, the operator might input planned and executed friendly troop movements to permit estimates of the likelihood that the enemy detected the movements. This routine could be considered in combination with number 10 which covers ECM Vulnerability Analysis.

13. Develop Intelligence Collection Pattern Analysis Routine.

This routine might use the ESD file entries concerning enemy intelligence collection activities plus additional inputs concerning the location of enemy electromagnetic collection devices to predict the probable goals of the enemy collection activities and the most likely future activities. Allied with number 12.

14. Change ESD Message Filter Function to Permit Redundancy Checking of All Incoming ESD Messages.

Current design of the ESD message filter function requires entry of specific values for subject, activity, location, agency and/or source. This requirement almost makes it mandatory that each analyst create and maintain his own filter sets and alter and add to them frequently. It was recommended that the requirement to identify specific messages for filtering be dropped and that only the specification relative criteria be required. This would require that all incoming messages go through a redundancy check. Any combination of messages that meet the criteria would be displayed to the operator who could combine the information in one message and delete the redundant or confirming messages.

15. Develop Automatically Summed Enemy Personnel and Equipment Losses and Calculate Combat Efficiency Percentages.

The analyst efforts to retrieve, correlate, filter, and sum enemy losses could be accomplished by TOS. It would also be necessary to compare the results to doctrinal strength to obtain the units current estimated combat strength. When completed, the EOB file should also be automatically updated to reflect the new percentages.

16. Develop Enemy Target Analysis Routine.

The routine could use data from the EOB, ESD, and TER files to predict the location of enemy targets such as command posts and supply areas.

17. Develop Alternate Courses of Action Routine.

A routine could be developed for TOS that would aid the operations planners in assessing potential courses of action considering factors such as objectives, avenues of approach, weather, terrain, obstacles, force disposition, and supporting attack requirements. Enhancement number 8 is allied to this one.

18. Develop a Routine to Produce Operational Summaries.

The files could be manipulated to produce operational situation summaries for review by the commanders and staff. These tabular or graphic displays need to be summed, calculated, and displayed automatically so that the commander and staff can readily identify potential weak areas. The exact type and definition of these displays needs to be defined and might include such areas as: weapons systems availability, CAS committments and availability, personnel summary, logistics summary, fallout summary, significant events summary, etc. These data might be superimposed over the current situation map individually for briefing purposes or displayed collectively for situation monitoring. This overall area is allied with inputs number 29 and 30 which are more specific examples.

19. Develop TOS/TACFIRE Target Assignment and Correlation Routine.

The G2 target intelligence loaded into TOS is expected to be automatically loaded into the ATI file of TACFIRE. A requirement exists to correlate the target as recorded in the two sets of files. The routine developed must permit correlation of the two files to permit subsequent updating and/or purging of both files simultaneously. This enhancement should be addressed as part of a TOS/TACFIRE Interoperability Study.

20. Develop Scheme for Inserting Battle Damage on ESD Targets.

This enhancement appeared in the original list of potential enhancement targets but was eliminated by SDC as being procedurally oriented and not data processing.

21. Develop an FSE Target Screen for Processing G2 Target Data to DIVARTY.

The current analysis of the range and location data of G2 target intelligence passed by TOS is expected to be accomplished by TACFIRE. Targets not meeting the range or area responsibility criteria will be passed to the FSE for further processing. A target screen based upon artillery assets and the DIVARTY area of responsibility could be described, developed, and loaded into TOS to filter and pass to TACFIRE only those targets within DIVARTY's engagement envelope.

22. Develop a Range Fan to Determine Friendly Vulnerability to Enemy Artillery.

Enemy artillery locations are an integral part of the G2 EOB file and could be used to assess the vulnerability of friendly artillery and forces to enemy fires. When an enemy artillery piece is identified and loaded in the EOB file, the proposed routine would begin by constructing a range fan equal to the artillery piece identified. The range fan could then be compared to all known friendly locations. Those falling within the range fan could be summed and presented to the operators in a tabular summary which might be ordered by: command and control locations, artillery locations (broken out by conventional-nuclear-chemical), rocket launching facilities, troop concentrations, airfields, etc. The same routine might also be used to determine enemy vulnerability to friendly weapons.

23. Develop Strike Warning Message Processing Procedures.

This enhancement appeared in the original list of potential enhancement targets but was eliminated by SDC as being primarily procedurally oriented and not data processing.

24. Provide Only Evaluated Burst Locations to TACFIRE for Fallout Prediction Generation.

TACFIRE fallout generation is initiated by introducing NBC-1 data through the VFMED. The TACFIRE burst location correlation problem would appear to be magnified by introducing large numbers of division generated NBC-1 data. The TACFIRE correlation problem could be minimized if TACFIRE would accept only evaluated burst locations (NBC-2) from the division for fallout generation (predicted). A correlation routine for converting NBC-1 into NBC-2 could easily be accomplished for TOS. The passing of this data automatically might also be considered as part of the TOS/TACFIRE interoperability problem.

25. Develop an NBC-4 Plotting Support Routine for NBC Operations.

NBC personnel are required to convert BDE and BN NBC-4 reported data into the four radiation contour lines from which actual fallout conditions can be determined. A TOS computer support program could be established that could rapidly calculate the contour patterns, conduct the analysis of which units will be effected and when, and develop the NBC-5 data for transmission to lower echelons.

26. Develop a Division Radiation Exposure File Using the Staff Working File Capability.

Develop procedures to satisfy the radiation exposure file requirement with the SWF. This file might then be an input into an analysis routine which could analyze fallout effects on units and present findings to the NBC personnel in terms of stay time, hot spots, protection methods, etc. There is a need to be able to SRI this file which cannot be done under the current TOS concept.

27. Develop a G4 Information Status Staff Working File.

G4 personnel need to develop a G4 data base using the staff working file capability. This data base could include such items as depot locations, quantities stocked, critical supplies, etc., in order to be able to respond to logistical problems of an immediate nature. This data base would then be a source of input to support routines which could be used in anticipating and planning logistical needs of the division.

28. Provide all Battalion Data Base Needs Automatically.

A requirement exists, at battalion, to provide potential staff users with their data base needs automatically to prevent a potential input - output problem for the only TOS console. This would eliminate the necessity to be constantly accessing the console to obtain data and permit the console to be utilized in a primary input role. The area needs further study before data processing can be applied.

29. Develop a Routine for Processing BIR Status.

Develop methodology for processing, summarizing, and displaying division status information using the BIR status reports. Data such as weapons systems availability and conditions could be extracted and presented to the staff in summary form to aid situation monitoring and decision making. This enhancement is closely related to number 18 and could be considered an application of that enhancement.

30. Develop a Routine to Use the BIR for Comparative Purposes.

Develop the necessary methodology for relating and comparing BIR data to projected gains and losses forecasted within the division. The output of the routine might be a tabular display presented to operations planners upon request to describe the potential impact of losses and gains in division assets.

31. Front Line Trace Processing.

Develop the technique for automatically computing the division front line trace based upon inputs from the lowest echelons (battalions and armored cavalry squadron). Additionally, the routine should inspect and keep track of the orientation of on-line units (order from left-to-right facing the enemy and overall direction of the enemy). This permits double-checking and notification of coordination point locations.

32. Compare and Automatically Recompute Areas of Interest Based on Changes in Battlefield Geometry.

Develop a routine to compare and automatically recompute, if necessary, areas of interest (NAI) to changing battlefield conditions (tactical dispositions) based upon correlated data from lower echelons.

33. Enemy Movement Processing and Prediction.

Develop routine that can provide warning/notification when movement of an enemy unit might indicate similar movement of superior/subordinate units.

34. Develop a Routine to Provide Attrition Predicitions.

Develop a software routine which can be used by the G1 to develop and produce attrition projections for future operations being contemplated. The routine might consider unit strengths and requisitions in developing its final projections. Projected loss tables will be required by this routine.

APPENDIX B

Potential Function Matrix

This appendix shows the task considerations and screens described in the text that were used to define the "boundries" and to determine the most im ortant of the potential TOS software applications.

POTENTIAL FUNCTION MATRIX - TO BE CONSIDERED

	POTENTIAL FUNCTION	TASK CONSIDERATIONS					SCREENS		
		a	b	c	d	e	1	2	3
21.	Develop FSE Target Screen for Processing G2 Target Data to DIVARTY	1	3	FSE	TA	1	N	Y	Y
22.	Develop Range Fan to Determine Friendly Vulnerability to Enemy Artillery	4	8	FSE	M/TA	1	N	Y	Y
25.	Develop NBC-4 Plotting Support for NBC Operations	3	7	NBC	M	1	N	Y	Y
29.	Develop Routine for Processing BIR Status	2	4	G3	TA	2	N	Y	Y
31.	Front Line Trace Processing	3	4	G3	TA	2	N	Y	Y
32.	Compare and Automatically Recompute Areas of Interest Based on Changes in Battlefield Geometry	3	7	G3	TA	2	N	Y	Y
34.	Develop a Routine to Provide Attrition Prediction	1	2	G1	M	2	N	Y	Y

<u>Task Considerations</u>

a. Number of echelons involved
b. Number of elements involved
c. Primary staff agency involved
d. Task identification
e. Criticality rating

<u>Screens</u>

1. Under study
2. Frequency and criticality
3. Primary staff agency and task commonality

N = No Y = Yes

POTENTIAL FUNCTION MATRIX - NOT TO BE CONSIDERED

	POTENTIAL FUNCTION	TASK CONSIDERATIONS a	b	c	d	e	SCREENS 1	2	3
	Primary Staff or Commonality								
19.	Develop TOS/TACFIRE Target Assignment and Correlation Routine*	1	3	FSE	TA	1	N	Y	N
	Frequency and Criticality								
1.	Develop Automatic Distribution Matrix Capability	4	24	G3	TA	4	N	N	–
	Under Study								
4.	Develop Road Movement Analysis Routine	1	2	G4	M	2	Y-TRW		
5.	Develop Enemy Troop Movement Analysis Routine	2	6	G2	TA	1	Y-TRW		
6.	Develop Pattern Analysis Routine to Predict Enemy's Intention	2	6	G2	TA	1	Y-TRW		
7.	Develop Order of Battle Analysis Routine	1	6	G2	TA	1	Y-TRW		
8.	Develop an Operational Planning Data Search	3	4	G3	TA	1	Y-TRW		
10.	Develop an ECM Vulnerability Analysis Routine	1	6	G2	TA	1	Y-TRW		

*Functions should be addressed as part of a TOS/TACFIRE interoperability study.

POTENTIAL FUNCTION MATRIX - NOT TO BE CONSIDERED

POTENTIAL FUNCTION	TASK CONSIDERATIONS					SCREENS		
	a	b	c	d	e	1	2	3
11. Develop G1 Information Status SWF	2	6	G1	M	2	Y-CTOS		
12. Develop a Routine for Projecting Enemy Analysis of Friendly Forces	2	6	G2	TA	2	Y-TRW		
13. Develop Intelligence Collection Pattern Analysis Routine	2	6	G2	TA	2	Y-TRW		
14. Change ESD Message Filter Function to Permit Redundancy Checking of all Incoming Messages	1	1	G2	TA	2	Y-CTOS		
15. Develop Automatically Summed Enemy Personnel and Equipment Losses and Calculate Combat Efficiency Percentages	1	2	G2	TA	1	Y-TRW		
16. Develop Enemy Target Analysis Routine	1	3	G2	TA	2	Y-TRW		
17. Develop Alternate Course of Action Routine	3	6	G3	TA	1	Y-CTOS		
18. Develop Routine to Produce Operational Summaries	3	12	G3	M	2	Y-CTOS		
24. Provide Only Evaluated Burst Locations to TACFIRE for Fallout Prediction Generation	3	4	NBC	M	1	Y-CTOS		

POTENTIAL FUNCTION MATRIX - NOT TO BE CONSIDERED

POTENTIAL FUNCTION	TASK CONSIDERATIONS					SCREENS		
	a	b	c	d	e	1	2	3
26. Develop Division Radiation Exposure File Using SWF Capability and Methodology to Screen It	3	4	NBC	TA	1	Y-CTOS		
27. Develop a G4 Information Status SWF	1	2	G4	M	2	Y-CTOS		
30. Develop Routine for Comparing BIR Data to Projected Gains	3	9	G3	TA	1	Y-CTOS		
33. Enemy Movement Processing and Prediction	3	6	G2	TA	2	Y-TRW		

APPENDIX C

Flow of Personnel Administration and Logistics Data in Two FORSCOM Divisions

This appendix illustrates the data collection form and describes in detail the flow of personnel administration and logistics data in the two FORSCOM divisions visited during the field survey.

Attrition Prediction

Personnel attrition forecasts may be based upon either nuclear-biological-chemical (NBC) or conventional operations. NBC loss estimates, treated in FM 101-10-3, are classified. Therefore, the following discussion is concerned only with conventional operations.

Personnel attrition forecasts at division level comprise two parts; an estimate of battle, non-battle, and total (battle plus non-battle) losses for the division as a whole, and a breakdown of these overall division losses into infantry, artillery, armor, engineers, and all other personnel. To compute overall loss predictions, the estimator's data needs are the division's current assigned strength and attrition factors from Table 5-8 in FM 101-10-1. For a breakdown by branch, battle losses are estimated using attrition factors from Table 5-9 in FM 101-10-1. However, non-battle loss estimates are handled differently. The estimator first determines the number of personnel authorized to the division as a whole, and the number authorized to each branch. He then computes the proportions of the division's authorized strength that are accounted for by the authorized strength of each branch (i.e., number of personnel authorized to the branch, divided by number of personnel authorized to the division). Multiplying the division's estimated non-battle losses by each proportion provides the branch's non-battle losses. Finally, of course, summing the branch battle and non-battle losses yields an estimate of total branch losses. The procedure must be repeated for each day of the projected operation; however, at the division level, losses are predicted only for five days or less.

Most of the data required for attrition prediction consists of constant values from tables in FM 101-10-1 or contained in the TOE. The only variable datum required is the division's assigned strength. This datum is available on a report called "Personnel Daily Summary" (PDS--Figure C-2) in one division, and "Personnel Manpower Report" (PERSREP--Figure C-3) in the other. The report originates at the company level, where the 1st Sergeant compiles personnel data from the platoons and sections. Sometimes by radio, but nearly always by courier, he submits the completed report to the battalion S1 section.

Treatment of company reports differs in some details in the two FORSCOM divisions. In both, the battalion S1 clerk-typist logs each company report as it arrives and posts it on an acetate-overlay S1 status board. After all company reports are received, logged, and posted, in one division the S1 consolidates the company reports and prepares the battalion report. In the other division, the S1 clerk-typist prepares the battalion report, and the S1 reviews it for completeness and accuracy. In both divisions, the completed report is transmitted to the brigade S1 section, normally by courier.

The remainder of the reporting procedure is essentially the same in the two divisions. The brigade S1 clerk-typist logs the arriving battalion reports and posts them to the brigade S1 status board. After all battalion reports

DATE: ____________________

TASK DATA COLLECTION FORM

INFORMATION SOURCE: ______________________ MONTHS OF RELATED EXPERIENCE: __________

DUTY POSITION: ______________________ MOS: ________ AUTOVON NUMBER: __________

FUNCTIONAL AREA: ______________________ UNIT: ______________________

TASK: ______________________ WHERE PERFORMED: ______________

PREDICTED PERFORMANCE TIME (minutes): ____ PREDICTED FREQUENCY PER SHIFT: ____

SKILLS REQUIRED: ____

____

JOB AIDS: ____

____

PRIMARY POSITION: ____

START QUE: ____

END QUE: ____

TASK STEPS:

____

____

____

____

____

____

Figure C-1. The recording sheet used during field data collection.

PERSONNEL DAILY SUMMARY					UNIT									AS OF DATE/TIME:									MESSAGE TO:								
		STRENGTH									DAILY LOSSES																				
	UNIT	AUTHORIZED			ASSIGNED			PRESENT FOR DUTY			CASUALTIES																				
											KILLED			WOUNDED			MISSING			CAPTURED			TOTAL			NON-BATTLE			ADMIN		
	A	B			C			D			E			F			G			H			I			J			K		
LINE		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1																															
2																															
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5																															
6																															
7																															
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10																															
	PAGE TOTAL																														

4D FORM 602 1 Aug 75 REPLACES FORM 3, WHICH MAY BE USED (CONTINUED ON REVERSE SIDE) (AFZA-GA) 4D TAC SOP

Figure C-2. Example of a personnel daily summary (PDS) used to report personnel status information in the one FORSCOM division.

PERSONNEL MANPOWER REPORT
(PERSREP)

1. FORMAT

(Security Classification)

Line #1: ______________________
(Reporting Headquarters)

Line #2: ______________________
(PERSREP NUMBER)

Line #3: ______________________
AS OF DATE/TIME

	STRENGTH		LOSSES DURING PERIOD							Gains During Period			Pers Red Con	Morale
			BATTLE				NON BATTLE							
	Authorized by TOE	Current Operating	KIA	WIA	MIA	PW	Killed	Injured or Disease	Admin	Replacements	Hosp Returnees	Admin		
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)
Line #4: Off														
Line #5: WO														
Line #6: Enl														
Line #7: Total														

COMBAT TASK ORGN: MAJOR SUBORDINATE COMMANDS (DIV, ACR, SEP BDE/GP)

a ______ *BDE/REGT/GP	AUTH STR	OPERATING STR	BDE/REGT/GP	% EFF	REMARKS
(1) ______________	TF/BN/SQDN	% EFF			Critical MOS & NR REQ
(2) ______________	TF/BN/SQDN	% EFF			

* (use separate lettered para for each BDE/REGT/GP with subpara for each TF/BN/SQDN in the REGT/BDE/GP)
b. DIV DS ARTY by BN showing BN pers % eff.
c. DIV TRPS NO OF BN AND OVERALL %. Show CAV SQDN separately w/% eff if DIV TRPS
d. RESERVE (indicates units in res and % eff)
e. DISCOM OVERALL %; NO BN IN DISCOM

(Security Classification)

FR FORM 1399

Figure C-3. Example of a Personnel Manpower Report (PERSREP) used to report personnel status information in one FORSCOM division.

have arrived, the brigade S1 shift officer prepares a brigade report, retaining battalion unit identifiers. The completed report is forwarded to the division G1 section, again usually by courier. The brigade reports are logged and posted on the division G1 status board, and the G1 prepares a division report for transmittal to corps G1.

Both the PDS and the PERSREP are submitted daily. Administration personnel at each echelon visited told SDC interviewers that the report--and indeed, administration data generally--would be useless if submitted less frequently.

For the most part, data processing of the PDS and PERSREP consists of posting data on status boards, transcribing it from one document to another, and consolidating data from lower echelons. Required computations are performed manually, either entirely with paper and pencil or with the aid of calculators. The manual data processing procedures employed at all levels appear to be significant source of error. Administration personnel reported that they frequently have to query lower echelons to resolve discrepancies, conflicts and missing data.

The approximate time required to prepare a personnel status report at one echelon and transmit it to the next echelon are shown in Table C-1. However, administration personnel at each of the echelons visited observed that these times are conservative in one respect. If a report from a lower echelon is delivered by courier under blackout conditions, transmittal can take as much as three times as long as in daylight.

The data in the PDS and PERSREP are used by the G1 and the AG for a variety of purposes; the only one of these that concerns this report, of course, is personnel attrition prediction. For this purpose, assigned strength is merely extracted from the division report or from the division G1 status board.

Division administration personnel agreed that personnel attrition prediction is an important G1 function in fulfilling his tactical responsibilities. They also expressed their belief that attrition factors in FM 101-10-1 provide estimates that are accurate within 5 or 10 percent, and that this accuracy is adequate for replacement planning purposes and for evaluation of projected operations. In one division, they also expressed doubt that upgrading the tables or developing procedures to assess experience factors would be worth the trouble. However, personnel at both divisions emphatically expressed a need for procedures to predict losses by MOS and grade. They also observed that the current manual procedure is unwieldy and time consuming and that they would welcome any relief from computational burdens in this respect.

<u>Logistics status reporting.</u> Ten major classes of supply are listed in FM 101-10-1:

TABLE C-1

APPROXIMATE TIMES IN MINUTES REQUIRED TO PREPARE AND DELIVER PERSONNEL DAILY SUMMARY (PDS) AND PERSONNEL MANPOWER REPORT (PERSREP)

	REPORT	
ECHELON	PDS	PERSREP
Company	60	30
Battalion	30	60
Brigade	30	60
Division	45	20
TOTAL	165	170

I. (subsistance)--includes rations, water, etc.

II. (clothing)--items of wearing apparel and accessories.

III. (POL)--fuel, lubricants, etc.

IV. (construction)--building materials used by engineers.

V. (ammunition)--all NBC and conventional ammunition supplies.

VI. (personnel demand items)--nonmilitary sales items such as razor blades, soap, and other personal items.

VII. (major end items)--includes all major equipment items such as tarks, personnel carriers, fuel tank trucks, etc.

VIII. (medical material)--all medical supplies including medical repair kits.

IX. (repair parts)--all repair parts and components required for equipment repair.

X. (material to support nonmilitary programs)--includes all supplies, not included in above classes, that are used to support nonmilitary programs, for example, agricultural and economic development assistance.

Logistics personnel in both FORSCOM divisions agreed that no one class of supply is inherently more important than the others, because a sudden acute shortage of virtually any class (probably excepting VI and X) can threaten the success of an operation. Nonetheless, they indicated that Classes I, II, IV, VI, VIII, IX, and X seldom if ever impact tactical decision making or operations significantly. SDC personnel therefore eliminated these classes from further consideration.

Classes III (POL) and V (ammunition) certainly have great importance tactically, for obvious reasons. Units in both divisions keep records on the status of both POL and ammunition supplies. However, these records primarily serve local needs, and neither class ordinarily appears in reports from lower to higher echelons. The exception is an actual or impending critical shortage of either--or indeed, of any class of supply. Such shortages are reported through "spot reports." However, normally both POL and ammunition are "push driven." POL supplies are located in the brigade trains and are released to units as needed. As supplies are dispensed, quantities are reported back to the Division Material Management Center (DMMC) of the Division Support Command (DISCOM). Similarly, ammunition supplies are located at Ammunition Supply Points (ASPs) in the brigade areas and are released to units in accordance with a Controlled Supply Rate (CSR) determined in advance by corps. As supplies are dispensed, quantities are reported back, in one division to DISCOM and in the other directly to the G4. Daily reports on ammunition and POL status are sent from DMMC to the G4 in both divisions. The G4 uses these reports in briefing the commander.

Because POL and ammunition are push driven in this manner, they normally have relatively little impact on tactical reporting. Indeed, the G3 at one division told the SDC interviewer that he was seldom concerned with POL and ammunition. As far as logistics was concerned, his most urgent requirement was accurate and up-to-date information about the status of equipment. Further, because of the relatively short reporting chain, there are relatively fewer problems in reporting POL and ammunition than in reporting Class VII items, discussed immediately below. For these reasons, Classes III and V did not seem to require inclusion in future versions of TOS.

That Class VII items received the greatest interest and attention in both the FORSCOM divisions is scarcely surprising. The major weapons and support equipment comprising this class have obvious tactical importance, and their importance is reflected in their prominence in the logistics reporting system. While individual units keep their own records on several classes of supply, formal reports originating in the companies focus on Class VII items. In one division, such reports are submitted on a daily basis, while in the other they typically are submitted only on demand or whenever a change in status occurs.

One report, the Material Readiness Report (DA Form 2406--Figure C-4), is common to both divisions. Its purpose is to report the status of equipment items designated by the division commander. Another, called the Daily Battle Loss Report in one division and the Battle Loss Report[1] in the other, is used to report combat losses of equipment, as their titles imply. Finally, one division uses a Special Status of Selected Items (SSSI--Figure C-5) Report. This report basically duplicates information already available on the 2406, although the SSSI does not contain the maintenance information entered on the 2406. At the time of the SDC visit, G4 personnel in this division were seeking approval to eliminate the SSSI.

Data for logistics reporting that originate in the company are assembled by the company Executive Officer (XO), who also functions as the Motor Officer, or by his Motor Sergeant. He prepares the appropriate report and transmits it to the battalion S4 section, either by courier or the admin/log net, depending on the specific report and/or prevailing conditions. The battalion S4 NCOIC logs the company report and posts it to the S4 status board. When all company reports have been received, he consolidates the company data, prepares the battalion report, and submits the completed report to the S4 for approval. The approved report is transmitted to the brigade S4 section. The brigade S4 NCOIC logs incoming battalion reports and posts them to the S4 status board. When all battalion reports have been received, copies are delivered intact and without consolidation to the DMMC. The DMMC consolidates the battalion reports daily and transmits them by RATT to the corps MMC, with information copies to the division G4 section. The G4 NCOIC reviews the reports and posts them on the G4 status boards. If they contain significant information, he brings them to the attention of the G4.

There is relatively little data processing as logistics information moves upward through the echelons. Data are consolidated at the company and battalion levels, but thereafter retain their battalion identities. Totals are calculated at each reporting level, and percentages are computed to show percentages of operationally ready equipment for each reported item. The times required to prepare the 2406 report at each echelon are shown in Table C-2. These times are representative of other reports; they are also highly approximate, however. Depending on prevailing conditions, they can vary greatly. Division personnel observed that the time required to consolidate and transmit reports from the company level to division varies from about three and a half hours to more than 13.

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1. No illustration of either version of the report is presented here because neither division uses a standard printed form. Instead, a single line is transmitted by radio or RATT for each item, consisting of the unit identifier, the equipment's TOE line number, and the numbers of the item authorized, on hand lost in the past 24 hours, due in, and requisitioned.

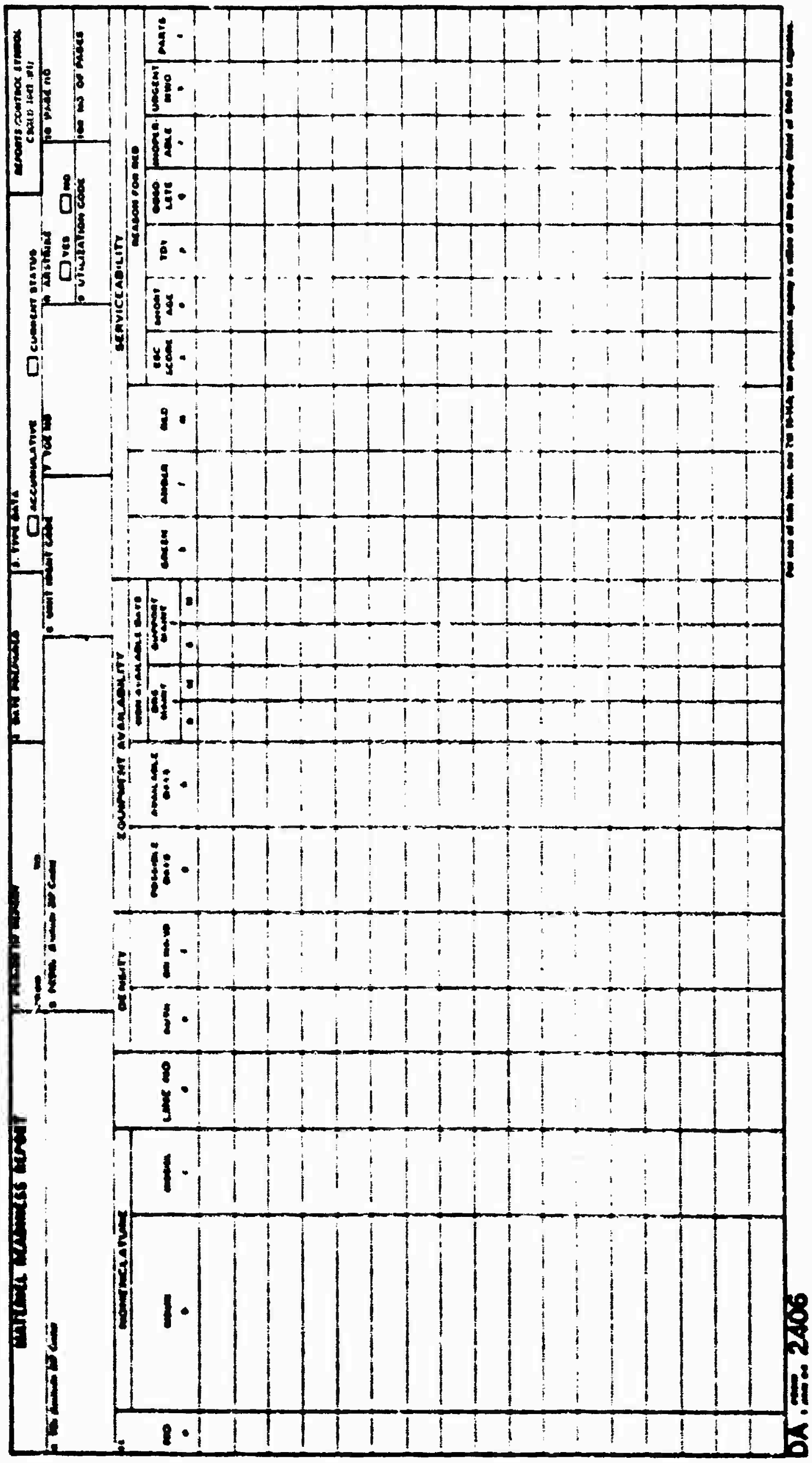


Figure C-4. The Material Readiness Report (DA Form 2406) used to report the status of selected items of equipment in both divisions.

SPECIAL STATUS OF SELECTED ITEMS (SSSI)

FROM ______________ (REPORTING UNIT) AS OF: ______________

LINE (B)	UNIT (C)	NUMBER AUTHORIZED (D)	NUMBER ON HAND (E)	BUMPER NUMBER NON-AVAL	CURRENT REPAIR LEVEL (F)	REASON ITEM NON-AVAL (G)	DUE IN (H)	REQUIRED (I)

Figure C-5. The Special Status of Selected Items (SSSI) Report used to report the status of selected items of equipment in one division.

The numbers of Class VII items reported via the logistics chain varied considerably from one division to another, reflecting differences in commanders' guidance. Although procedures differed in details between the two, in both divisions the information provided to the G4 consisted essentially of a daily summary of the status of selected items extracted from the 2406 and spot reports.

G4 personnel agreed that their greatest and most pressing problem was to obtain timely information that was accurate. One individual stated that, at best, his information is usually four hours old. All G4 personnel interviewed were particularly concerned about accurate, timely Class VII data because these data relate to the major weapons employed in tactical operations, are used in determining unit operating efficiency, and contribute to the computation of combat power. They also agreed that any improvements to Class VII reporting should include both tactical and support equipment, but that priority naturally should be given to tactical equipment.

TABLE C-2

APPROXIMATE TIMES REQUIRED TO PREPARE THE MATERIAL READINESS REPORT (DA FORM 2406)

ECHELON	DIVISION 1	DIVISION 2
Company	15	60
Battalion	60	20
Brigade	60	15
Division	60	60

Note 1: Times are shown in number of minutes

Note 2: The above times are for preparation only. Delivery consumes from about 15 minutes to as much as 4 hours, depending on conditions.

The problem of timeliness has two aspects. First is the time required to receive the data from lower echelons and then to assemble the data and prepare the report. Second is the time required to transmit reports from one echelon to the next higher echelon. Combined, preparation time and sequential reporting can consume as many as 13 hours between the company and division levels.

The problem of accuracy appears to stem from a combination of sequential reporting and human performance. That is, data are compiled at the company level, then relayed through the battalion and brigade to division. At every level, human beings are required to transcribe, consolidate, transmit, or in some other fashion manipulate the data. Of course, every human being in the reporting chain is a source of error, through omission, commission, or transposition. Thus every point in the reporting chain provides an opportunity for errors to creep into the data.

APPENDIX D

Materials Used in the Evaluation Experiment

This appendix describes and illustrates the materials used for subject matter presentation and data collection during the experiment to evaluate the recommended TOS software application.

BACKGROUND INFORMATION FROM PARTICIPANTS IN EXPERIMENT COMPARING TWO METHODS OF DATA ORGANIZATION AND PRESENTATION

Team No. ________

"G1-S1" ____ "G4-S4" ____

1. Rank ____________

2. Duty MOS __________

3. Previous duty assignment ______________________________

4. Months of experience in previous duty assignment ____________________

5. Have you had experience in an S1 or G1 section? ________ If so, for how many months? ____________

6. Have you had experience in an S4 or G4 section? ________ If so, for how many months? ____________

7. If you have had experience either in an S1 or S4 section, please describe briefly your major duties during that experience.

8. Have you attended any personnel or logistics schools or courses?

______________ If so, please list them below.

Figure D-1. An example of the Background Information Form completed by each participant in the experiment.

After you have solved each problem, please rate the usefulness of the solution to that problem by answering the following questions.

A. How would you rate the value of the solution to this problem?

1	2	3	4	5
Not Valuable At All	Marginally Valuable	Moderately Valuable	Very Valuable	Extremely Valuable--Critically Important

B. How would you rate the usefulness or value of the solution relative to the amount of effort required to obtain that solution?

1	2	3	4	5
Value Much Less Than Effort	Value Moderately Less Than Effort	Value Equal To Effort	Value Moderately Greater Than Effort	Value Much Greater Than Effort

Figure D-2. The rating scale used by participants to assign values to problem solutions and to assign values of solutions compared to effort required to obtain the solution.

PERSONNEL MANPOWER STATUS

HEADQUARTERS	PERSREP #		AS OF DATE TIME							EFFECTIVE OPERATING STRENGTH				
54th Div			110930PJUL76							94				
	STRENGTH		LOSSES DURING PERIOD							GAINS DURING PERIOD			PERS RED CON	MORALE
			BATTLE			NON BATTLE								
	AUTH/TOE	CURRENT OPERATING	KIA	WIA	MIA	PW	KILLED	INJ	ADMIN	REPL	HOSP	ADMIN		
OFF	1130	1072												
WO	358	304												
ENL	16269	15444												
TOTAL	17757	16820												
REMARKS	CRITICAL MOS & #REQ													

HEADQUARTERS	PERSREP #		AS OF DATE TIME							EFFECTIVE OPERATING STRENGTH				
	STRENGTH		LOSSES DURING PERIOD							GAINS DURING PERIOD			PERS RED CON	MORALE
			BATTLE			NON BATTLE								
	AUTH/TOE	CURRENT OPERATING	KIA	WIA	MIA	PW	KILLED	INJ	ADMIN	REPL	HOSP	ADMIN		
OFF														
WO														
ENL														
TOTAL														
REMARKS	CRITICAL MOS & #REQ													

Figure D-3. An example of the Personnel Manpower Report used in [illegible] experiment.

OPERATIONS READY CHART

1ST BDE

AS OF 110930PJUL78

	1-104			2-104			3-104					
	AUTH	O/H	O/R	AUTH	O/H	O/R	AUTH	O/H	O/R	AUTH	O/H	O/R
M60	51	48	47	51	45	44	51	39	39			
M113	3	2	1	3	3	2	3	3	3			
M106												
TOW												
M577												
M578												
M88												
DRAGON												
COMBAT POWER			88			85			77			

Figure D-4. An Operations Ready Chart for the 1st Brigade.

OPERATIONS READY CHART

2ND BDE

AS OF 110930PJUL78

	1-38			2-38			3-38					
	AUTH	O/H	O/R	AUTH	O/H	O/R	AUTH	O/H	O/R	AUTH	O/H	O/R
M60	51	45	42	51	40	35	51	37	35			
M113	3	2	0	3	2	0	3	2	0			
M106												
TOW												
M577												
M578												
M88												
DRAGON												
COMBAT POWER			77			64			68			

Figure D-5. An Operations Ready Chart for the 2nd Brigade.

OPERATIONS READY CHART

3RD BDE

AS OF 110930PJUL78

	1-63			2-63			3-63					
	AUTH	O/H	O/R	AUTH	O/H	O/R	AUTH	O/H	O/R	AUTH	O/H	O/R
M60	51	39	36	51	43	40	51	35	30			
M113	3	3	2	3	2	1	3	2	2			
M106												
M577												
M578												
M88												
DRAGON												
COMBAT POWER			70			75			59			

Figure D-6. An Operations Ready Chart for the 3rd Brigade.

SAMPLE PROBLEM - DATA BASE

SYSTEM M60A2

	SYSTEMS	EQUIPMENT			CREW AVAILABILITY			
UNIT	OP-RDY	OP-RDY	REPAIR	LOST	CMDR	GUNNER	DRIVER	LOADER
54 ARMOR DIV	346	348	23	88	352	373	385	387
1st Bde	130	130	2	21	132	133	135	136
A/1-104		14	1	2				
B/1-104		16	0	1				
C/1-104		13	0	4				
BN/1-104		43	1	7				
A/2-104		15	0	2				
B/2-104		14	0	3				
C/2-104		15	0	2				
BN/2-104		44	0	7				
A/3-104		15	0	2				
B/3-104		13	1	3				
C/3-104		15	0	2				
BN/3-104		43	1	7				
2nd Bde	110	112	10	31	110	125	130	128
A/1-38		13	1	3				
B/1-38		14	1	2				
C/1-38		12	1	4				
BN/1-38		39	3	9				
A/2-38		12	1	4				
B/2-38		13	1	3				
C/2-38		12	2	3				
BN/2-38		37	4	10				

Figure D-7. Part of a supplemental M60A2 data base used by the experimenter to answer questions in the manual method.

SAMPLE PROBLEM - DATA BASE

SYSTEM M60A2

UNIT	OP-RDY	EQUIPMENT OP-RDY	EQUIPMENT REPAIR	EQUIPMENT LOST	CREW AVAILABILITY CMDR	CREW AVAILABILITY GUNNER	CREW AVAILABILITY DRIVER	CREW AVAILABILITY LOADER
A/3-38		12	1	4				
B/3-38		12	1	4				
C/3-38		12	1	4				
BN/3-38		36	3	12				
3rd Bde		106	11	36	110	115	120	123
A/1-63		12	2	3				
B/1-63		11	1	5				
C/1-63		12	1	4				
BN/1-63		35	4	12				
A/2-63		11	2	4				
B/2-63		13	0	4				
C/2-63		12	1	4				
BN/2-63		36	3	12				
A/3-63		12	1	4				
B/3-63		11	2	4				
C/3-63		12	1	4				
BN/3-63		35	4	12				

OTHER REQUIRED DATA FOR SAMPLE QUESTIONS

DIV AUTH STRENGTH		DIV ASGN STRENGTH		DIV AUTH ARMOR PERSONNEL	DIV AUTH M60A2 CREW PERSONNEL
OFF	1130	OFF	1102	2200	1836
WO	358	WO	319		
EM	16269	EM	15989		
TOTAL	17757	TOTAL	17410		

Figure D-8. The remainder of the supplemental M60A2 data used by the experimenter to answer questions in the manual method.

Explanation of Simulated Displays for the TOS Method

(a) Personnel strength report. This display (Figure D-9) was designed primarily to display assigned and authorized strengths, quantities that are required for calculating personnel and weapons systems attrition forecasts. Present for duty strength and personnel due in were added at the suggestion of a subject expert who noted that S1 and G1 personnel are accustomed to seeing all four quantities.

UNIT: 58 DIV TIME: 301215CAUG78

AUTHORIZED			ASSIGNED		
OFF	WO	EM	OFF	WO	EM
1138	358	16269	1088	342	15548

PRESENT-FOR-DUTY			DUE-IN		
OFF	WO	EM	OFF	WO	EM
1060	330	15124	28	12	424

Figure D-9. A Simulated TOS Personnel Strength Report

(b) Personnel attrition forecast. This display (Figure D-10) shows predicted personnel losses to a division for a particular type of operation. A separate display is provided for each of the first five days of the operation. Cumulative losses as the operation continues are shown at the right side of the display. Overall losses are shown as battle, non-battle, and total losses, and these are further broken down according to branch.

UNIT: 58 INF (MECH) DIV TIME: 301230CAUG78

TYPE-OF-OPERATION: DEFENSE OF POSITION

	DAY-1-OF-OPERATION			CUMULATIVE-FOR-OPERATION		
	BATTLE	NON-BATTLE	TOTAL	BATTLE	NON-BATTLE	TOTAL
OVERALL-LOSSES	323	50	373	323	50	373
LOSSES-BY-BRANCH						
INFANTRY	200	12	212	200	12	212
ARTILLERY	12	4	16	12	4	16
ARMOR	74	6	80	74	6	80
ENGINEERS	11	3	14	11	3	14
ALL-OTHERS	26	25	51	26	25	51

Figure D-10. A simulated TOS Personnel Attrition Forecast.

(c) Weapon system attrition forecast. This dislay (Figure D-11) shows predicted losses of major components of the M60A2 system for a particular type of operation. A forecast generated for each day of the operation is shown at the left side of the display, and cumulative losses as the operation continues are shown at the right side. Equipment losses and total crew losses are shown first, broken down by battle, non-battle, and total losses. Then, total crew losses are further broken down by crew position.

FORECAST-FOR: M60A2 OF: 58 INF (MECH) DIV TIME: 301230CAUG78

TYPE-OF-OPERATION: DEFENSE OF POSITION

	DAY-1-OF-OPERATION			CUMULATIVE-FOR-OPERATION		
	BATTLE	NON-BATTLE	TOTAL	BATTLE	NON-BATTLE	TOTAL
EQUIP LOSSES	11	1	12	11	1	12
CREW LOSSES	30	2	32	30	2	32
CMDR	13	1	14	13	1	14
GUNNER	8	1	9	8	1	9
DRIVER	5	0	5	5	0	5
LOADER	4	0	4	4	0	4

Figure D-11. A Simulated TOS Weapon System Attrition Forecast.

(d) Unit/system status report. This display (Figure D-12) shows the status of a particular weapon system (for example, the M60A2) for a specific unit (for example, A Company of the 3rd of the 64th Armor). The second line of the display shows the current status of the unit's equipment component of the system. Below this line, the display presents the status of the system's crew components. The "System" column under "Authorized" and "% OP-RDY" reflect the numbers of personnel authorized for M60A2 systems. Since the TOE authorizes more armor personnel to a unit than are actually needed for tanks, the "TOE" columns show the total numbers of authorized personnel at each skill level. Below the crew component status, the display shows overall system status. For this experiment, an operational system was defined as a "ready to fight" tank with a full four-man crew. Note that this definition is equal to the smallest number available of any of the five major components. At the bottom of the display, personnel and equipment considerations are presented for obtaining more operational systems. "Quick Fix" number 1 shows how more systems can be obtained by adding some number of one component type; the second quick fix shows how to obtain even more systems by adding some number of one component type, and some number of a second component type. Note in Figure D-12 that no second quick fix is presented because only one component (equipment) is currently in short supply.

STATUS OF M60A2 FOR A/3-64 TIME: 301140CAUG78

EQUIP AUTH: 17 OP-RDY 15 REPAIR 0 LOST: 2 %-OP-RDY: 88

JOB	AUTHORIZED SYSTEM	AUTHORIZED TOE	AVAIL	SHORTAGE SYSTEM	SHORTAGE TOE	%-OP-RDY SYSTEM	%-OP-RDY TOE
CMDR	17	19	17	0	2	100	89
GUNNER	17	17	17	0	0	100	100
DRIVER	17	20	17	0	3	100	85
LOADER	17	20	17	0	3	100	85

SYSTEM AUTH: 17 OP-RDY: 15 SHORTAGE: 2 %-OP-RDY: 88

	QUICK-FIX	ADDED SYSTEMS	RESULTING %-OP-RDY
1:	2 Equip	2	100
2:			

Figure D-12. A Simulated TOS Unit/System Status Report for a Single Company.

Figure D-13 shows a Unit/System Status Report obtained by "rolling up" the data for a battalion's companies, including its Headquarters and Headquarters Company. In similar fashion, data can be rolled-up to obtain status for a brigade, and for the division as a whole.

STATUS OF M60A2 FOR 3-64 TIME: 301200CAUG78

EQUIP AUTH: 54 OP-RDY: 49 REPAIR: 3 LOST: 2 %-OP-RDY: 90

JOB	AUTHORIZED SYSTEM	TOE	AVAIL	SHORTAGE SYSTEM	TOE	%-OP-RDY SYSTEM	TOE
CMDR	54	60	52	2	8	96	86
GUNNER	54	54	51	3	3	94	94
DRIVER	54	63	51	3	12	94	80
LOADER	54	63	50	4	13	92	79

SYSTEM AUTH: 54 OP-RDY: 47 SHORTAGE: 7 %-OP-RDY: 87

	QUICK-FIX	ADDED SYSTEMS	RESULTING %-OP-RDY
1:	1 EQUIP	1	92
2:	2 EQUIP AND 1 LOADER	2	94

Figure D-13. A Simulated TOS Unit/System Status Report for a Single Battalion.

(e) Weapon system status summary. Figure D-14 shows a weapon system status summary for a single battalion. Data are extracted from each company's unit/system status report and presented selectively on a single display. Note that only systems are shown in the display; the component breakdown is not included. The first and second greatest shortages are shown at the right of the display.

STATUS SUMMARY FOR M60A2

UNIT	TIME	% OR	GREATEST-SHORTAGES ONE	TWO
HH/3-64	301155CAUG78	100		
A/3-64	301140CAUG78	88	2 EQUIP	
B/3-64	301145CAUG78	88		
C/3-64	301150CAUG78	82		

Figure D-14. A Simulated TOS Weapon System Status Summary Report for a Single Battalion.

(f) Weapon system status -- unit summary. Figure D-15 shows a weapon system status -- unit summary for a single battalion. The purpose of the unit summary is to show the status of all of a unit's major weapon system assets. The unit summary can be generated for any unit, and at any echelon from company to division. The example in Figure D-15 shows only two systems, the two used in the experiment. Of course, it could show as many systems as necessary, in accordance with commanders' guidance.

STATUS SUMMARY FOR 3-64

SYSTEM	TIME	% OR	GREATEST-SHORTAGES ONE	TWO
M60A2	501155CAUG78	87	4 LOADERS	2 EQUIP
M220A1	301200CAUG78	75		

Figure D-15. A Simulated TOS Weapon System Status--Unit Summary Report for a Single Battalion.

(g) Weapon system status -- component summary. Figure D-16 shows the last of the displays used for the experiment, the weapon system status -- component summary. The purpose of this display is to show the status of a single system component for all the units under a given echelon. Figure D-16, for example, shows the status of the division's tank commanders, broken down by brigade. Two columns in the display deserve special mention. The "EXCESS (component description, e.g., CMDR, EQUIP)" column will be blank if the number available of the component being displayed is less than or equal to the number available of the component in shortest supply. If the number available of this component is greater than the number available of the component in shortest display, then this column will contain the difference between the numbers available of the two components. Similarly, the "CRIT SHORT" column will be blank unless the component being displayed also happens to be the component in shortest supply. In that case, the column will show the number of this component needed to bring it up equal to the component in next shortest supply.

STATUS OF CMDR FOR M60A2

UNIT	AUTH SYS	AVAILABLE SYS	AVAILABLE CMDR	EXCESS CMDR	SHORT	TIME
2 BDE	54	46	48	2		301020CAUG78
3 BDE	162	146	153	13		301200CAUG78

Figure D-16. A Simulated TOS Weapon System Status--Component Summary Report for a Division.

TABLE D-1. THE PROBLEM SOLVING SITUATION USED FOR THE TRAINING SESSION.

Problem Solving Situation - Example

General Background

After months of diplomatic confrontations and increasing tensions, an aggressor nation invaded the United States, and war was declared. Immediately after the invasion, the aggressor announced that it had not used nuclear weapons during the attack. It pledged that it would not use such weapons except in retaliation for nuclear strikes against its own forces or national territory. Thus far, it has honored that pledge and the President of the United States accordingly has ordered American forces to wage only conventional warfare.

Problem Solving Situation - Phase 1

The 54th Armored Division is deployed in fortified positions along a 50-kilomter front. These positions are critical to plans for a forthcoming general offensive, and the 54th will therefore be permitted to withdraw only on orders from Corps. Corps G2 has advised the Division to expect an attack in force between 12 and 36 hours from now. Best estimates are that the attack will come in 18 hours, at dawn, and will be directed primarily at the center of the Division's front. Presently, the 1st Brigade is deployed in this sector, with the 2nd Brigade to the south and the 3rd to the north.

The 54th has already beaten back two probing attacks and has suffered losses. Personnel and material for replacement are critically short right now, although the situation is expected to ease within a few days. The Division has been advised to submit requisitions as appropriate, but to plan to conduct at least the early phase of the battle with existing resources.

TABLE D-2. THE WORKSHEET USED BY PARTICIPANTS IN CALCULATING SOLUTIONS TO PROBLEMS IN PERSONNEL AND WEAPON SYSTEM ATTRITION PREDICTION.

PERSONNEL AND WEAPON SYSTEM ATTRITION WORKSHEET

	Day 1	Day 2	Day 3	Day 4	Day 5
Assigned Strength					
Overall Losses:					
A. Battle	___	___	___	___	___
B. Non-Battle	___	___	___	___	___
C. Total	___	___	___	___	___
Losses by Branch:					
A. Infantry	___	___	___	___	___
B. Artillery	___	___	___	___	___
C. Armor	___	___	___	___	___
D. Engineers	___	___	___	___	___
E. All Others	___	___	___	___	___
M60A2 System:					
A. Crews	___	___	___	___	___
B. Tanks	___	___	___	___	___
C. Commanders	___	___	___	___	___
D. Gunners	___	___	___	___	___
E. Drivers	___	___	___	___	___
F. Loaders					

TABLE D-3. THE PROCEDURE GIVEN TO PARTICIPANTS FOR USE IN FORECASTING WEAPON SYSTEM ATTRITION FOR THE M60A2.

PROCEDURE FOR ESTIMATING NUMBERS OF M60A2 TANK AND/OR TANK CREW LOSSES DURING A GIVEN DAY OF AN ENGAGEMENT

1. Using Table 5-8 in FM 101-10-1, estimate the numbers of battle losses and non-battle losses.

2. Using values for armor in Table 5-9 of FM 101-10-1, estimate the number of armor personnel (MOS 12B and 19D) battle losses.

3. Estimate the number of armor personnel (MOS 12B and 19D) non-battle losses as follows: a) divide the authorized number of armor personnel in the Division by the total authorized number of personnel in the Division; and b) multiply the number of non-battle losses obtained in 1 above by the decimal fraction obtained in 3a above.

4. Add the value obtained in 2 above to the value obtained in 3b above, to obtain the estimate of the total number of armor personnel losses.

5. Divide the number of crewmen authorized for M60A2 tanks by the total number of authorized armor personnel.

6. To estimate M60A2 personnel losses, multiply the number of armor personnel losses obtained in 4 above by the decimal fraction obtained in 5 above.

7. To estimate the number of M60A2 tank losses, divide the number of tank personnel losses obtained in 6 above by 2.6 and round off to a whole number.

8. To estimate numbers of losses for specific M60A2 tank crew members, multiply the number of tank personnel losses obtained in 6 above by the appropriate decimal fraction below, and round off to a whole number:

For commanders, use	.43
For gunners, use	.28
For drivers, use	.16
For loaders, use	.13

TABLE D-4. THE PROBLEMS SOLVED BY PARTICIPANTS DURING THE TRAINING SESSION.

PRACTICE QUESTIONS

1. What percentage of the Division's authorized strength is currently present for duty?

SOLUTION:________

USEFULNESS:______

2. How many M60A2 tanks are operationally ready in the 2nd Brigade?

SOLUTION:________

USEFULNESS:______

3. How many M60A2 loaders are available in the Division?

SOLUTION:________

USEFULNESS:______

4. How many M60A2 tanks are operationally ready in Bravo Company in the 2nd of the 38th?

SOLUTION:________

USEFULNESS:______

5. How many personnel can the Division expect to lose during the 1st day of the coming engagement?

SOLUTION:________

USEFULNESS:______

6. Of the personnel losses estimated in problem 5 above, how many can be expected to occur among armor personnel?

SOLUTION:________

USEFULNESS:______

TABLE D-4. Continued.

7. How many losses can be expected among M60A2 crewmen on the 1st day of the coming engagement?

SOLUTION:________

USEFULNESS:______

8. How many M60A2 tanks can the Division expect to lose during the 1st day of the coming engagement?

SOLUTION:________

USEFULNESS:______

TABLE D-5. PROBLEM SOLVING SITUATION 1, PHASE 1.

PROBLEM SOLVING SITUATION

Situation

An aggressor nation has invaded the United States, landing from the Gulf of Mexico and pushing northward on a broad front. The aggressor achieved dramatic gains early in the conflict, but stiffening resistance by American forces has stalled his advance at least temporarily. However, intelligence reports indicate that the aggressor has been preparing for a general offensive and that his preparations are very nearly complete.

Thus far, neither side has employed nuclear, biological, or chemical weapons. The President of the United States has pledged that America will not be the first to employ such weapons. He has directed American forces to conduct conventional warfare so long as the aggressor continues to do so.

Current Status

The 58th Infantry Division (Mechanized) has seen frequent action since shortly after the invasion and participated in the battle that stalled the enemy advance. Presently, the Division is deployed along a 50-kilometer front, facing south. On the west flank, the Division's 1st Brigade occupies positions in rugged, mountainous terrain. The 2nd Brigade's center positions are located in an area of low hills. The 3rd Brigade occupies positions on the east flank, in an area of relatively flat plains. At present, the Brigades are task organized as follows:

1st BDE: 1st of the 68th Inf, 3rd of the 26th Inf, 3rd of the 134th Inf

2nd BDE: 2nd of the 134th Inf, 3rd of the 68th Inf, 1st of the 38th AR

3rd BDE: 1st of the 134th Inf, 2nd of the 29th AR, 2nd of the 38th AR, 3rd of the 64th AR

Notified of intelligence reports of an impending attack on his positions, the Division Commander and his staff are planning for the coming engagement. Because the Division occupies critical positions, its manning factor is presently 100% of TOE. At the moment, the Commander and his staff are concerned with certain aspects of overall strength, and with the Division's tank battalions.

The Commander has directed that, at least for the time being, equipment that is currently being repaired will not be considered available for the coming engagement. He has also directed that weapon systems are to be considered operationally ready only if they presently have a full crew. Finally, the Commander has directed that weapon crew vacancies are not to be filled by promotion until after all arriving replacements have been assigned.

Before proceeding to solve problems please address any questions you may have to Dr. Parrish.

TABLE D-6. PROBLEM SOLVING SITUATION 1, PHASE 2.

Problem Solving Situation - Phase II

The aggressor attacks all along the Division's front, but with its main thrust directed at the 1st Brigade. The 2nd and 3rd are engaged, but only lightly. The Division Commander therefore detaches units from these Brigades to reinforce the 1st. After intensive fighting for 5 days, the enemy disengages and begins to withdraw. The Division Commander reassigns task forces to their respective brigades.

The 58th is ordered to pursue the enemy force, but not to engage the enemy again until resupply is accomplished. The replacement problem has eased somewhat, but is still severe. The Division Commander therefore decides to maximize his combat effectiveness first by shifting personnel and equipment as appropriate, and then assigning replacements where needed as they arrive.

TABLE D-7. PROBLEM SOLVING SITUATION 2, PHASE 1.

PROBLEM SOLVING SITUATION

Situation

An aggressor nation has invaded the United States, landing from the Gulf of Mexico and pushing northward on a broad front. The aggressor achieved dramatic gains early in the conflict, but stiffening resistance by American forces has stalled his advance. Now, American forces are planning a counterattack.

Thus far, neither side has employed nuclear, biological, or chemical weapons. The President of the United States has pledged that America will not be the first to employ such weapons. He has directed American forces to conduct conventional warfare so long as the aggressor continues to do so.

Current Status

The 58th Infantry Division (Mechanized) has seen frequent action since shortly after the invasion, and participated in the battle that halted the enemy advance. Presently, the Division is deployed in positions along a 50-kilometer front, facing south. Its positions are located in an area of gently rolling hills, and it will attack enemy positions in similar terrain during the offensive.

The Division's 1st Brigade occupies the west flank, the 2nd Brigade is located in the center, and the 3rd Brigade occupies the east flank. The Brigades currently are task organized as follows:

1st BDE: 1st of the 68th Inf, 2nd of the 68th Inf, 1st of the 38th AR

2nd BDE: 3rd of the 68th Inf, 1st of the 134th Inf, 2nd of the 29th AR, 3rd of the 64th AR

3rd BDE: 2nd of the 134th Inf, 3rd of the 134th Inf, 2nd of the 38th AR

The Division Commander and his staff are planning for the coming engagement. Because the Division occupies critical positions, its manning factor is 100% of TOE. At the moment, the Commander and his staff are concerned with general questions of strength and with the tank battalions.

TABLE D-7. Continued.

The Commander directs that, at least for the time being, equipment that is currently being repaired will not be considered available for the coming engagement. He further directs that weapon systems will not be considered operationally ready unless they have a full crew. Finally, he has directed that weapon crew vacancies are not to be filled by promotion until after all replacements have been assigned to units.

Before proceeding to solve problems, please address any questions you may have to Mr. Stevens.

TABLE D-8. PROBLEM SOLVING SITUATION 2, PHASE 2.

The Division Commander and his staff complete the rest of their planning. The Commander decides to maintain his task organization as described earlier. The attack is launched and substantial gains are made during 5 days of heavy fighting. The 58th, with other divisions, is ordered to prepare to defend its positions against an anticipated enemy counterattack.

The Commander directs that, at least for the time being, equipment that is currently being repaired will not be considered available for the coming engagement. He further directs that weapon systems will not be considered operationally ready unless they have a full crew. Finally, he directs that weapon crew vacancies are not to be filled by promotion until after all replacements have been assigned to units.

Before proceeding to solve problems, please address any questions you may have to Mr. Stevens.

APPENDIX E

Analyses of Variance of the Data Obtained From the Evaluation Experiment

TABLE E-1. ANALYSIS OF VARIANCE OF PROBLEM SOLUTION TIMES FOR THE FIRST GROUP OF 40 PROBLEMS.

Analysis of Variance

Source of Variation	df	SS	MS	F
I. Between Teams	19	37,596,394.49		
1. Methods (M)	1	22,877,674.52	22,877,674.52	30.422**
2. Situations (S)	1	734,402.82	734,402.82	0.977
3. M x S	1	1,952,187.60	1,952,187.60	2.596
4. Teams w/M x S	16	12,032,129.55	752,008.09	
II. Within Teams	60	44,817,736.20		
1. Problem Types (T)	1	1,286,005.62	1,286,005.62	1.578
2. M x T	1	443,275.30	443,275.30	0.544
3. S x T	1	1,023,102.60	1,023,102.60	1.256
4. M x S x T	1	973,949.13	973,949.13	1.195
5. Teams x T w/M x S	16	13,036,514.05	814,782.13	
6. Problem Categories (P)	1	550,290.32	550,290.32	0.889
7. M x P	1	4,413,771.00	4,413,771.00	7.127*
8. S x P	1	327,040.30	327,040.30	0.528
9. M x S x P	1	100,182.03	100,182.03	0.162
10. Teams x P w/M x S	16	9,909,305.05	619,331.57	
11. T x P	1	2,171,075.50	2,171,075.50	3.648
12. M x T x P	1	333,207.13	333,207.13	0.560
13. S x T x P	1	549,958.63	549,958.63	0.924
14. M x S x T x P	1	179,077.79	179,077.79	0.301
15. Teams x T x P w/M x S	16	9,520,981.75	595,061.36	
III. Total	79	82,414,130.69		

*$.01<p<.025$ **$.0005<p<.001$

TABLE E-2. ANALYSIS OF VARIANCE OF NUMBERS OF CORRECT ANSWERS FOR THE FIRST GROUP OF 40 PROBLEMS.

Analysis of Variance

	Source of Variation	df	SS	MS	F
I.	Between Teams	19	243.2375		
	1. Methods (M)	1	108.1125	108.1125	14.938**
	2. Situations (S)	1	0.3125	0.3125	0.043
	3. M x S	1	19.0125	19.0125	2.627
	4. Teams w/M x S	16	115.8000	7.2375	
II.	Within Teams	60	361.2500		
	1. Problem Types (T)	1	2.1125	2.1125	0.554
	2. M x T	1	7.8125	7.8125	2.049
	3. S x T	1	4.5125	4.5125	1.184
	4. M x S x T	1	0.3125	0.3125	0.082
	5. Teams x T w/M x S	16	61.0000	3.8125	
	6. Problem Categories (P)	1	0.0125	0.0125	0.002
	7. M x P	1	43.5125	43.5125	8.152*
	8. S x P	1	43.5125	43.5125	8.152*
	9. M x S x P	1	0.3125	0.3125	0.059
	10. Teams x P w/M x S	16	85.4000	5.3375	
	11. T x P	1	19.0125	19.0125	3.579
	12. M x T x P	1	0.6125	0.6125	0.115
	13. S x T x P	1	4.5125	4.5125	0.849
	14. M x S x T x P	1	3.6125	3.6125	0.680
	15. Teams x T x P w/M x S	16	85.0000	5.3125	
III.	Total	79	604.4875		

*$.01<p<.025$ **$.001<p<.005$

TABLE E-3. ANALYSIS OF VARIANCE OF PARTICIPANTS' RATINGS OF VALUES OF SOLUTIONS TO THE FIRST GROUP OF 40 PROBLEMS.

Analysis of Variance

	Source of Variation	df	SS	MS	F
I.	Between Teams	19	32.6375		
	1. Methods (M)	1	12.0125	12.0125	10.063*
	2. Situations (S)	1	0.0125	0.0125	0.010
	3. M x S	1	1.5125	1.5125	1.267
	4. Teams w/M x S	16	19.1000	1.1938	
II.	Within Teams	60	26.7500		
	1. Problem Types (T)	1	0.6125	0.6125	1.307
	2. M x T	1	0.0125	0.0125	0.027
	3. S x T	1	2.1125	2.1125	4.507*
	4. M x S x T	1	1.0125	1.0125	2.160
	5. Teams x T w/M x S	16	7.5000	0.4688	
	6. Problem Categories (P)	1	1.0125	1.0125	1.705
	7. M x P	1	0.1125	0.1125	0.189
	8. S x P	1	0.3125	0.3125	0.526
	9. M x S x P	1	0.3125	0.3125	0.526
	10. Teams x P w/M x S	16	9.5000	0.5938	
	11. T x P	1	0.3125	0.3125	1.429
	12. M x T x P	1	0.0125	0.0125	0.057
	13. S x T x P	1	0.1125	0.1125	0.514
	14. M x S x T x P	1	0.3125	0.3125	1.429
	15. Teams x T x P w/M x S	16	3.5000	0.2188	
III.	Total	79	59.3875		

*$.025<p<.05$ **$.05<p<.01$

TABLE E-4. ANALYSIS OF VARIANCE OF PARTICIPANTS' RATINGS OF VALUES OF PROBLEM SOLUTIONS RELATIVE TO EFFORT REQUIRED TO OBTAIN THEM FOR THE FIRST GROUP OF 40 PROBLEMS.

Analysis of Variance

	Source of Variation	df	SS	MS	F
I.	Between Teams	19	30.6375		
	1. Methods (M)	1	10.5125	10.5125	10.194*
	2. Situations (S)	1	1.5125	1.5125	1.467
	3. M x S	1	2.1125	2.1125	2.048
	4. Teams w/M x S	16	16.5000	1.0312	
II.	Within Teams	60	28.2500		
	1. Problem Types (T)	1	1.0125	1.0125	2.492
	2. M x T	1	0.1125	0.1125	0.277
	3. S x T	1	1.5125	1.5125	3.723
	4. M x S x T	1	0.6125	0.6125	1.508
	5. Teams x T w/M x S	16	6.5000	0.4062	
	6. Problem Categories (P)	1	0.3125	0.3125	0.435
	7. M x P	1	0.6125	0.6125	0.852
	8. S x P	1	1.0125	1.0125	1.409
	9. M x S x P	1	0.3125	0.3125	0.435
	10. Teams x P w/M x S	16	11.5000	0.7188	
	11. T x P	1	0.3125	0.3125	1.282
	12. M x T x P	1	0.3125	0.3125	1.282
	13. S x T x P	1	0.1125	0.1125	0.462
	14. M x S x T x P	1	0.1125	0.1125	0.462
	15. Teams x T x P w/M x S	16	3.9000	0.2438	
III.	Total	79	58.8875		

*.05<p<.01

TABLE E-5. ANALYSIS OF VARIANCE OF ORDER EFFECTS IN THE PROBLEM SOLUTION TIMES FOR THE TOS METHOD.

Analysis of Variance

Source of Variation	df	SS	MS	F
I. Between Teams	9	1,273,204.012		
1. Situations	1	88,245.612	88,245.612	0.596
2. Teams w/S	8	1,184,958.400	148,119.800	
II. Within Teams	70	4,310,226.375		
1. Groups of Problems (G)	1	317,646.012	317,646.012	11.184*
2. S x G	1	59,132.813	59,132.813	2.082
3. Teams x G w/S	8	227,210.800	28,401.350	
4. Problem Types (T)	1	173,445.312	173,445.312	8.903*
5. S x T	1	4,161.613	4,161.613	0.214
6. Teams x T w/S	8	155,854.200	19,481.775	
7. Problem Categories (P)	1	1,582,875.112	1,582,875.112	32.345**
8. S x P	1	19,065.313	19,065.313	0.390
9. Teams x P w/S	8	391,494.700	48,936.375	
10. G x T	1	2,679.613	2,679.613	0.461
11. S x G x T	1	1;593.112	1,593.112	0.274
12. Teams x G x T w/S	8	46,515.400	5,814.425	
13. G x P	1	10,192.613	10,192.613	0.727
14. S x G x P	1	13,755.012	13,755.012	0.981
15. Teams x G x P w/S	8	112,182.500	14,022.8125	
16. T x P	1	484,071.613	484,071.613	9.492*
17. S x T x P	1	11,068.512	11,068.512	0.217
18. Teams x T x P w/S	8	407,991.500	50,998.9375	
19. G x T x P	1	40,185.612	40,185.612	1.579
20. S x G x T x P	1	45,458.113	45,458.113	1.786
21. Teams x G x T x P w/S	8	203,646.900	25,455.8625	
III. Total	79	5,583,430.387		

$^{*}.01<p<.025$ $^{**}.0005<p<.001$

TABLE E-6. ANALYSIS OF VARIANCE OF ORDER EFFECTS IN THE NUMBERS OF CORRECT SOLUTIONS FOR THE TOS METHOD.

Analysis of Variance

	Source of Variation	df	SS	MS	F
I.	Between Teams	9	26.8125		
	1. Situations (S)	1	2.1125	2.1125	0.684
	2. Teams w/S	8	24.7000	3.0875	
II.	Within Teams				
	1. Groups of Problems (G)	1	0.0125	0.0125	0.009
	2. S x G	1	5.5125	5.5125	3.973
	3. Teams x G w/S	8	11.1000	1.3875	
	4. Problem Types (T)	1	13.6125	13.6125	6.849*
	5. S x T	1	0.6125	0.6125	0.308
	6. Teams x T w/S	8	15.9000	1.9875	
	7. Problem Categories (P)	1	56.1125	56.1125	17.813**
	8. S x P	1	15.3125	15.3125	4.861
	9. Teams x P w/S	8	25.2000	3.1500	
	10. G x T	1	0.3125	0.3125	0.258
	11. S x G x T	1	0.6125	0.6125	0.505
	12. Teams x G x T w/S	8	9.7000	1.2125	
	13. G x P	1	1.0125	1.0125	1.446
	14. S x G x P	1	4.5125	4.5125	6.446*
	15. Teams x G x P w/S	8	5.6000	0.7000	
	16. T x P	1	21.0125	21.0125	5.679*
	17. S x T x P	1	0.0125	0.0125	0.003
	18. Teams x T x P w/S	8	29.6000	3.7000	
	19. G x T x P	1	0.3125	0.3125	0.212
	20. S x G x T x P	1	0.0125	0.0125	0.008
	21. Teams x G x T x P w/S	8	11.8000	1.4750	
III.	Total	79	254.6875		

$*.1<p<.05$ $**.001<p<.005$

TABLE E-7. ANALYSIS OF VARIANCE OF ORDER EFFECTS IN THE PARTICIPANTS' RATINGS OF VALUE OF PROBLEM SOLUTIONS FOR THE TOS METHOD.

Analysis of Variance

	Source of Variation	df	SS	MS	F
I.	Between Teams	9	17.1125		
	1. Situations (S)	1	1.5125	1.5125	0.776
	2. Teams w/S	8	15.6000	1.9500	
II.	Within Teams	70	13.3750		
	1. Groups of Problems (G)	1	0.1125	0.1125	0.900
	2. S x G	1	0.0125	0.0125	0.100
	3. Teams x G w/S	8	1.0000	0.1250	
	4. Problem Types (T)	1	0.0125	0.0125	0.067
	5. S x T	1	0.1125	0.1125	0.600
	6. Teams x T w/S	8	1.5000	0.1875	
	7. Problem Categories (P)	1	0.1125	0.1125	0.310
	8. S x P	1	0.1125	0.1125	0.310
	9. Teams x P w/S	8	2.9000	0.3625	
	10. G x T	1	0.6125	0.6125	3.267
	11. S x G x T	1	0.0125	0.0125	0.067
	12. Teams x G x T w/S	8	1.5000	0.1875	
	13. G x P	1	1.0125	1.0125	16.200*
	14. S x G x P	1	0.1125	0.1125	1.800
	15. Teams x G x P w/S	8	0.5000	0.0625	
	16. T x P	1	0.6125	0.6125	2.227
	17. S x T x P	1	0.3125	0.3125	1.136
	18. Teams x T x P w/S	8	2.2000	0.2750	
	19. G x T x P	1	0.1125	0.1125	2.25
	20. S x G x T x P	1	0.1125	0.1125	2.25
	21. Teams x G x T x P w/S	8	0.4000	0.0500	
III.	Total	79			

*$.001<p<.005$

TABLE E-8. ANALYSIS OF VARIANCE OF ORDER EFFECTS IN THE RATINGS OF VALUE OF PROBLEM SOLUTION RELATIVE TO EFFORT FOR THE TOS METHOD.

Analysis of Variance

	Source of Solution	df	SS	MS	F
I.	Between Teams	9	14.95		
	1. Situations (S)	1	5.00	5.0000	4.020
	2. Teams w/S	8	9.95	1.2438	
II.	Within Teams	70	19.00		
	1. Groups of Problems (G)	1	0.45	0.4500	4.235
	2. S x G	1	0.20	0.2000	1.882
	3. Teams x G w/S	8	0.85	0.1062	
	4. Problem Types (T)	1	0.05	0.0500	0.205
	5. S x T	1	0.00	0.0000	0.000
	6. Teams x T w/S	8	1.95	0.2438	
	7. Problem Categories (P)	1	0.45	0.4500	0.935
	8. S x P	1	0.20	0.2000	0.416
	9. Teams x P w/S	8	3.85	0.4812	
	10. G x T	1	1.25	1.2500	4.878
	11. S x G x T	1	0.20	0.2000	0.780
	12. Teams x G x T w/S	8	2.05	0.2562	
	13. G x P	1	0.45	0.4500	2.323
	14. S x G x P	1	0.00	0.0000	0.000
	15. Teams x G x P w/S	8	1.55	0.1938	
	16. T x P	1	0.45	0.4500	0.889
	17. S x T x P	1	0.00	0.0000	0.000
	18. Teams x T x P w/S	8	4.05	0.5062	
	19. G x T x P	1	0.45	0.4500	6.545*
	20. S x G x T x P	1	0.00	0.0000	0.000
	21. Teams x G x T x P w/S	8	0.55	0.0688	
III.	Total	79			

*.10<p<.05

APPENDIX F

Implementation Requirements For The Recommended Application

INTRODUCTION

SDC recommends that TOS developers implement a software application to predict, report, and validate the status of major tactical equipment and personnel in the Army division. The proposed application would facilitate personnel attrition prediction, extend the attrition prediction concept to selected weapon systems, and provide for revision of attrition forecasts based on local experience. Further, it would provide status reports for command staff personnel while simultaneously providing data for validation of previous attrition forecasts. A conceptual description of the application was provided earlier, under "Weapon System Status Assessment." This appendix describes in detail the requirements and considerations involved in implementing the recommended application. Although it is conceived as a single personnel and weapon system status assessment package, the application would best be implemented in three separate program routines, described below.

GENERAL CONSIDERATIONS

In the discussion of implementation requirements and considerations, several general issues should be kept in mind.

Reporting Level

At present, TOS is intended for inputs to originate at the maneuver battalion level. Thus, information originating, for example, in the squad is "rolled up" manually through the platoon and company levels before it is reported to battalion. At battalion, it is consolidated across companies before entry into TOS, where it then becomes available to both brigade and division simultaneously.

The disadvantages of sequential reporting have already been discussed in this report. SDC therefore believes that status data should be reported from the lowest feasible level. This is not to suggest that TOS Input Output Devices (IODs) be allocated to echelons below the battalion level. Instead, a small, inexpensive, hand-held input device could be used at the company level or below to reduce the possibility of error being introduced into the data base and increase the timeliness of the data. The importance of source data reporting for both accuracy and timeliness cannot be overemphasized. Nonetheless, the suggested application neither requires nor depends on reporting at any particular echelon. Whether source data reporting is adopted or data enter the TOS at battalion, brigade, or even division, the application still provides utility to admin and log functions, though utility could potentially be degraded significantly as the reporting level is moved upward.

Task Organization

According to subject matter experts from the TMO, the Unit Task Organization File (UTO) is designed to facilitate commanders' task organizations of subordinate units. Indeed, the structure of the file would accomodate task organization down to the level of the individual soldier, although to SDC's knowledge no one seriously contemplates such a possibility. G1 and G4 personnel at both the FORSCOM divisions visited stated that some of their greatest problems in keeping track of assets arise from task organization. Data entry at the lowest feasible level would enable the recommended application to alleviate these problems. For example, if information were available at the platoon level, then the application could roll up the data and display the status of all assets currently available to a given company team or task force.

Moreover, reporting at these levels would alleviate another problem cited during interviews at the two FORSCOM divisions. Because they are usually not as well acquainted with attached units as with their own units, personnel in the receiving units experience difficulties in reporting the status of assets in the cross-attached units. If the platoon leader or company commander could report his own status, team and task force commanders should have fewer reporting problems.

Brigade and Battalion Trains

However the reporting system might finally be configured, a TOS IOD would be needed at both the brigade and battalion trains, if the proposed application is to provide maximum utility. If terminals are not provided at these locations, the S1 and the S4 effectively will be eliminated from the information network, thereby diminishing their ability to contribute to the division's mission. If reporting at the lowest feasible level is rejected, then the need for terminals at the trains will be particularly acute. Source data for revised attrition predictions, status reporting, and validation of attrition forecasts will be transmitted by lower echelons to the battalion trains. If the battalion S1 and S4 do not have a terminal, then that data will have to be transmitted in turn to the TOC for entry into TOS, imposing another time delay and another error source. And still, the brigade S1 and S4 would be shunted out of the information network.

Hierarchical Review

Under current manual methods, as data move up the reporting chain, they are reviewed for accuracy and completeness. Data reported to TOS from any level below that of division could pose a threat to hierarchical review. However, this threat can be countered. Again a terminal would be needed at brigade trains, and another at battalion trains for shared use by the S1 and S4 at each level. The terminal would provide the S1 and S4 access to the data base so that they could review data reported by subordinate units.

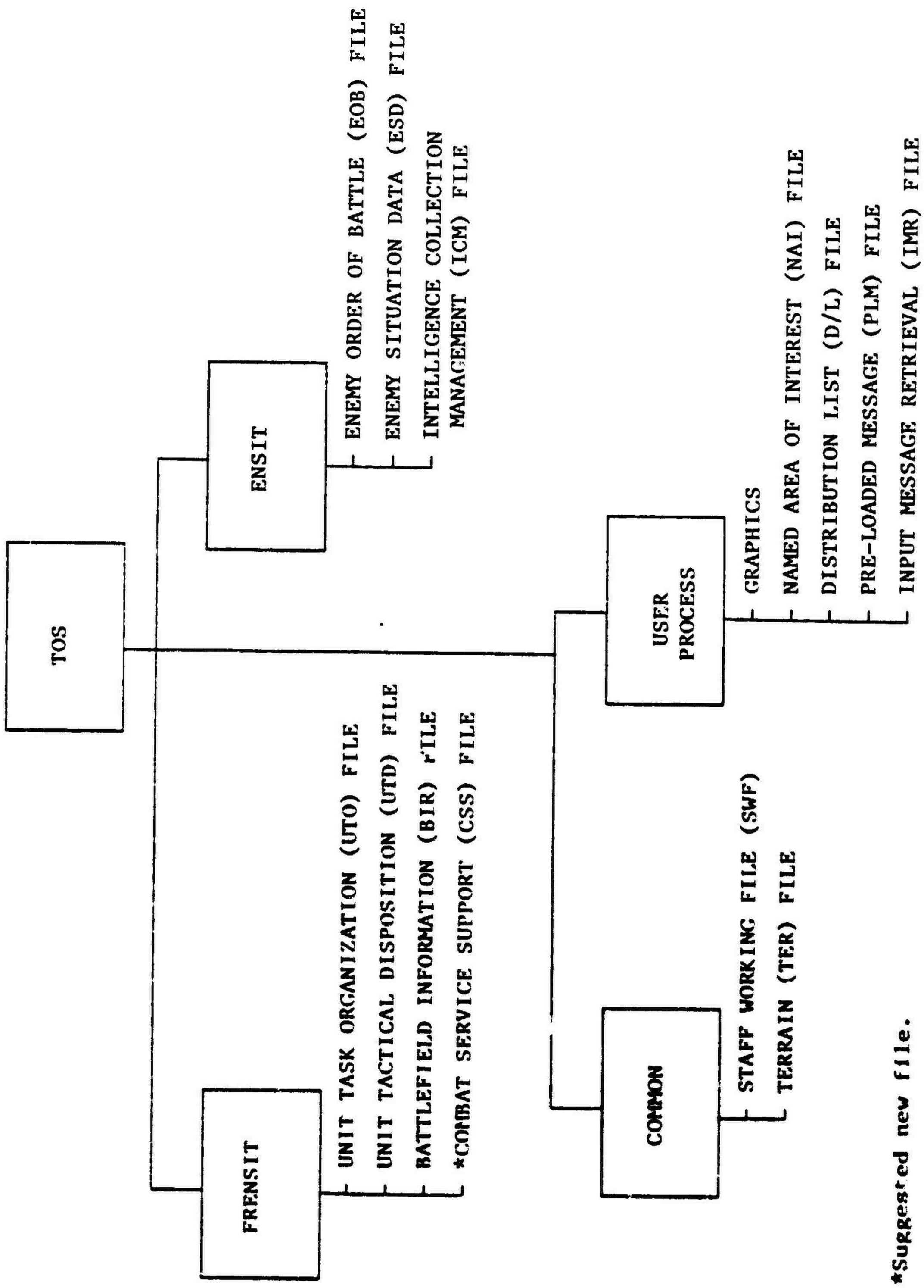
INFORMATION FILE

The proposed application creates a need for a new information file in TOS. This file, referred to hereafter as the Combat Service Support File (CSS), would contain all of the data required by the application except those data already resident in other files as described below. The decision to recommend a new file arises from consideration of files currently planned for TOS. After reviewing these files in the TOS System Specifications[1], the only logical repository for data related to the recommended application appeared to be the Staff Working File (SWF). However, there are a number of objections to using the SWF for this purpose. First, the algorithms used in generating initial and revised personnel and weapon systems attrition forecasts, and their associated attrition factor tables, require safe, permanent storage. The SWF doesn't meet this requirement, since it can be deleted. Second, weapon system status data also require safe and permanent storage, and must be accessible to roll up routines for summarizing data at the various echelons. This seems to be an unusual and undesirable application for the SWF. Finally, the design of the application envisions a potential sharing opportunity between the CSS and other TOS files. At present, data exchange with other files is not a SWF capability. A new file, designed specifically for admin/log applications, thus appears the best solution to the problem. The relationship of the CSS to other files is shown in Figure F-1.

A "master" software routine would provide access to specific routines within the application. The logic for this routine is flow-charted in Figure F-2. After CSS is called by the system, the master routine displays a "menu" (Figure F-3) of the application routines currently available in CSS. The user selects a specific routine by entering its associated number. If the input character is a 1, 2, 3, or 4, the master routine invokes the appropriate specific routine or returns to the system. If any other character is entered, it displays an error message (Figure F-4), and then requests the user to enter a C if he wishes to try again. Entering a C will result in a second display of the CSS menu. Otherwise, control reverts to the system or executive software.

---

1. System Specifications for the Division Tactical Operation System (DTOS). September 1978.



*Suggested new file.

Figure F-1. Relationship of current TOS information files and suggested new Combat Service Support (CSS) file.

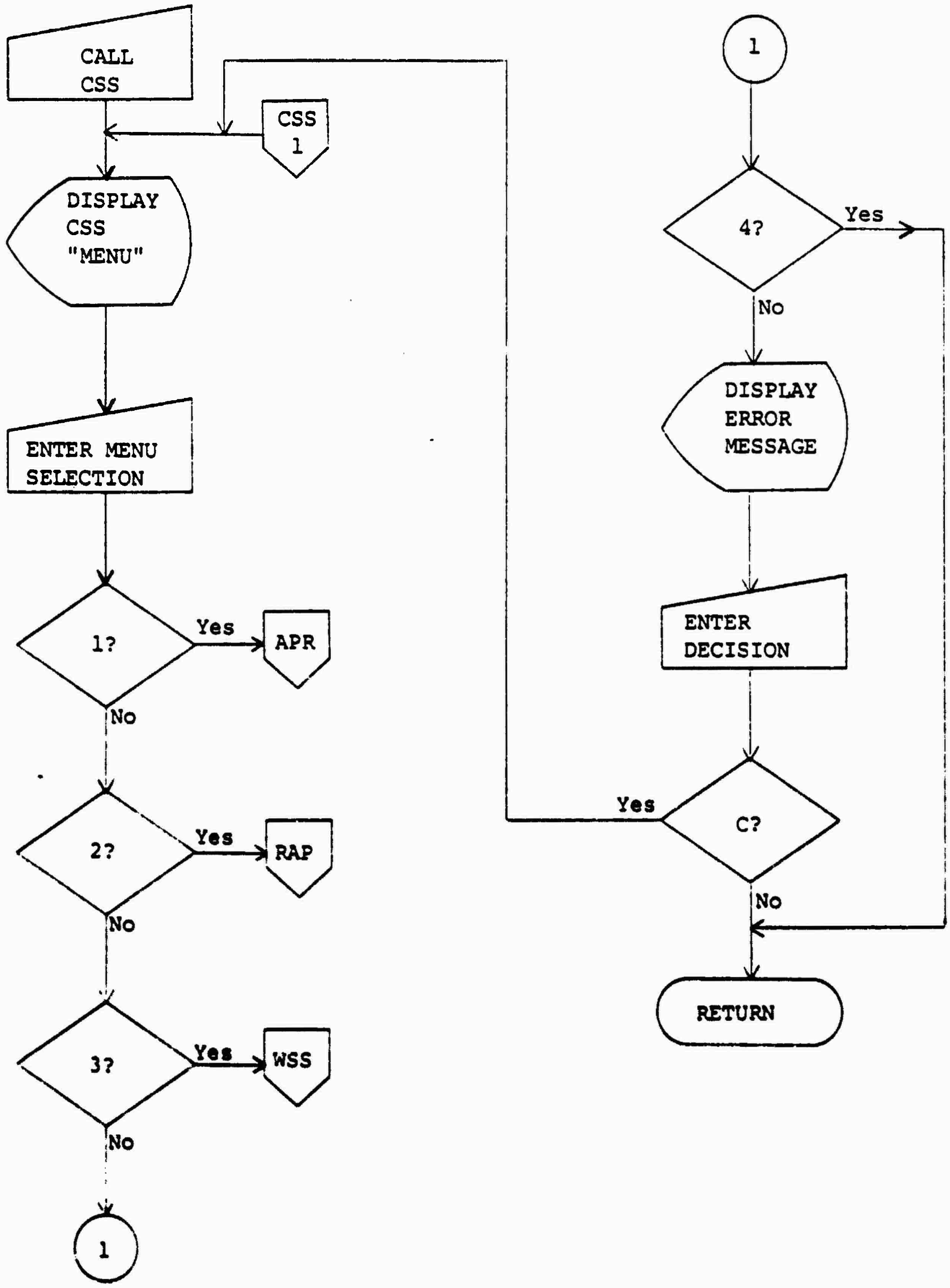


Figure F-2. Program flow for the CSS "Menu."

```
          111111111122222222223333333333444444444455555555556666666666777777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

THE COMBAT SERVICE SUPPORT FILE (CSS)
PROVIDES THE FOLLOWING ROUTINES:

1.  PERSONNEL/WEAPON SYSTEM ATTRITION FORECAST (APR)
2.  REVISED PERSONNEL/WEAPON SYSTEM ATTRITION FORECAST (RAP)
3.  WEAPON SYSTEM STATUS REPORT (WSS)
4.  RETURN TO TOS EXECUTIVE PROGRAM

ENTER THE NUMBER OF THE ROUTINE YOU WANT TO USE:  1
```

EXPLANATION

The display tells the user which functions the file can help him perform, then asks him to select the desired function by entering its number.

Figure F-3. The CSS "Menu."

```
         11111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

YOU SELECTED x, A NON EXISTENT ROUTINE.
ENTER C TO RETURN TO THE CSS MENU.
ENTER ANY OTHER CHARACTER TO RETURN TO SYSTEM CONTROL.

:
```

EXPLANATION

This display is presented only if the user enters anything except 1, 2, 3, or 4 after inspecting the CSS menu. It shows him his error, by replacing "x" in line 1 above with the value he entered. Them it gives him the option to go back to the CSS menu again, or to return to system control.

Figure F-4. Error message displayed by CSS if the user fails to select a legitimate function number.

Specific application routines are described immediately below.

ATTRITION PREDICTION ROUTINE (APR)

Attrition prediction (as opposed to revised attrition prediction described next) consists basically of three steps: (1) an overall forecast of division battle, non-battle, and total losses; (2) a breakdown of division losses by major Army branches; and (3) an attrition forecast for any or all of the weapon systems designated by commanders' guidance. The description of the prediction routine presented below uses the M60 system to exemplify weapon system attrition prediction. Attrition factors for the example were provided by the Administration Center's liaison officer at Fort Leavenworth. Similar factors would be required for each weapon system for which forecasts were desired.

Information Requirements

Information requirements for attrition forecasting consist of:

(a) Personnel attrition factors from Tables 5-8 and 5-9 of FM 101-10-1. Eventually, these factors would be replaced with newer factors developed in war games and other simulations, and from actual experience.

(b) Weapon system attrition factors.

(c) Type of division. The routine must use different attrition factors, depending on whether the forecast is for an infantry, armor, or airborne division. Subject matter experts expressed confidence that armor forecasts would be adequately accurate for mechanized divisions.

(d) Authorized strength. The system needs to know authorized strength for the division and for the infantry, artillery, armor, and engineer branches.

(e) Component names. Names of system components for each system to be recorded in TOS and for which attrition prediction will be performed. For example, for the M60 system, the names "EQUIPMENT" (or perhaps more simply, "EQUIP"), Commander ("CDR"), Gunner ("GNR"), Driver ("DVR"). and Loader ("LDR") would be required.

Presumably, the above data items would remain relatively constant, and therefore would be loaded into the CSS at system startup. Thereafter, the File Manager or System Controller would change or supplement them as new attrition factors and/or systems become available. The remaining items of required information, described below, would be entered by the user during execution of the routine.

(f) Mission name. At a given time, a division staff might be planning either sequential or alternative operations, or even both. Entering a mission name for each operation permits the routine to distinguish between them.

(g) Type of operation. Table 5-8 in FM 101-10-1 lists 10 different types of operations. There are different attrition factors for each, and the routine must select accordingly.

(h) Status of unit. Attrition factors also differ between divisions in contact and divisions in reserve, and the routine must select accordingly.

(i) Type of forecast desired. The routine can generate a personnel attrition forecast alone and then stop, or it can go on to generate a weapon system forecast as well.

(j) Weapon systems. If a weapon system forecast is desired, the routine must know for which systems it will generate forecasts.

(k) Assigned strength. The routine cannot obtain division assigned strength from the CSS; it must be entered through the suggested input display.

A suggested format for entering data items is presented in Figure F-5.

Data Processing

The routine accepts inputs from the user and then generates a personnel attrition forecast, including both overall division losses and a breakdown of losses by branch. This forecast is generated according to logic described in FM 101-10-1. An overview of the logic is presented in Figure F-6. Depending on the user's option, the routine then does one of two things. It may simply output a personnel attrition forecast and then return to the CSS menu. Or, if the user decides, it will go on to generate a weapon system attrition forecast for each system specified by the user. An overview of the logic for this function begins at "APR 1" in Figure F-6.

The authorized strength of system crewmen is divided by the authorized strength for the related branch. For example, the number of crewmen authorized for the M60A1 would be divided by the total number of authorized armor personnel. Or, the number of crewmen authorized for the M113A1 would be divided by the total number of infantry personnel. This computation yields a personnel attrition prediction factor for the system. This factor is multiplied by the total number of losses to the branch, yielding the number of crewmen losses to the system. To obtain the number of equipment losses, the number of crewmen losses

```
          11111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

MISSION-NAME: ALPHA          ASSIGNED-STRENGTH: 16978      TIME: 78/06/11/0930F

DIVISION-IN-CONTACT: Y       TYPE-OF-OPERATION: DEFENSE OF POSITION

WEAPON-SYSTEMS       : M60A1    : M113A1 : M222    : M88    :        :

                     :          :        :         :        :        :

PERSONNEL-WEAPON-FORECAST: B
```

EXPLANATION

1. Operator will be required to insert a mission name, the division's assigned strength, and time for the forecast.

2. The second line will include the operator input on whether or not the division is in contact (Y=yes, N=no) and the type of operation to be used to generate the forecast (10 options in clear text).

3. The third line permits the requestor to specify the weapon systems for which forecasts are to be generated (M numbers where possible should be used).

4. The last line gives the requestor control over the outputs. He may choose to have only a personnel forecast (P), a weapon forecast (W), or both (B).

Figure G-5. The Attrition Prediction Routine (APR) Input Display.

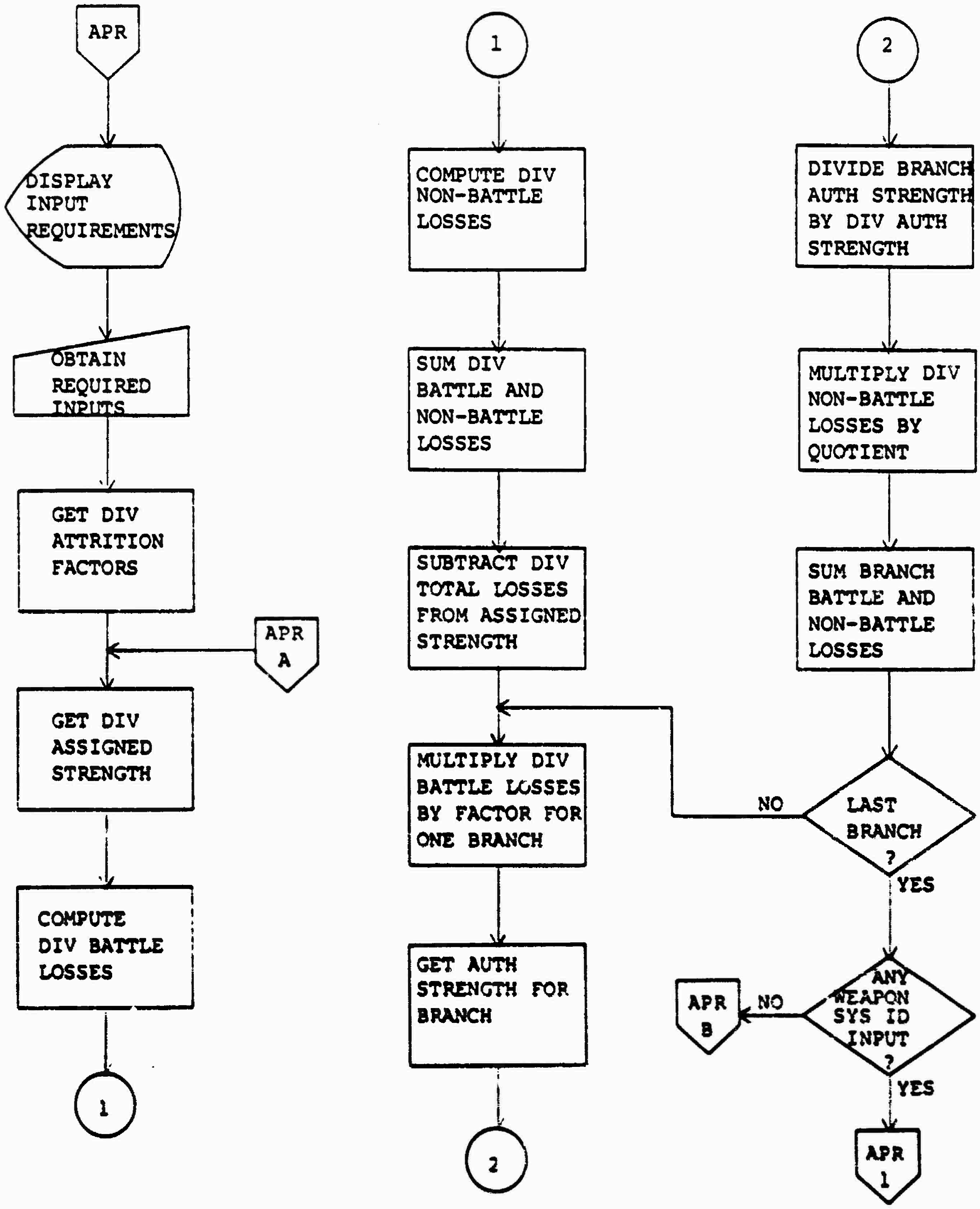


Figure F-6. Overview of the program flow for the Attrition Prediction Routine.

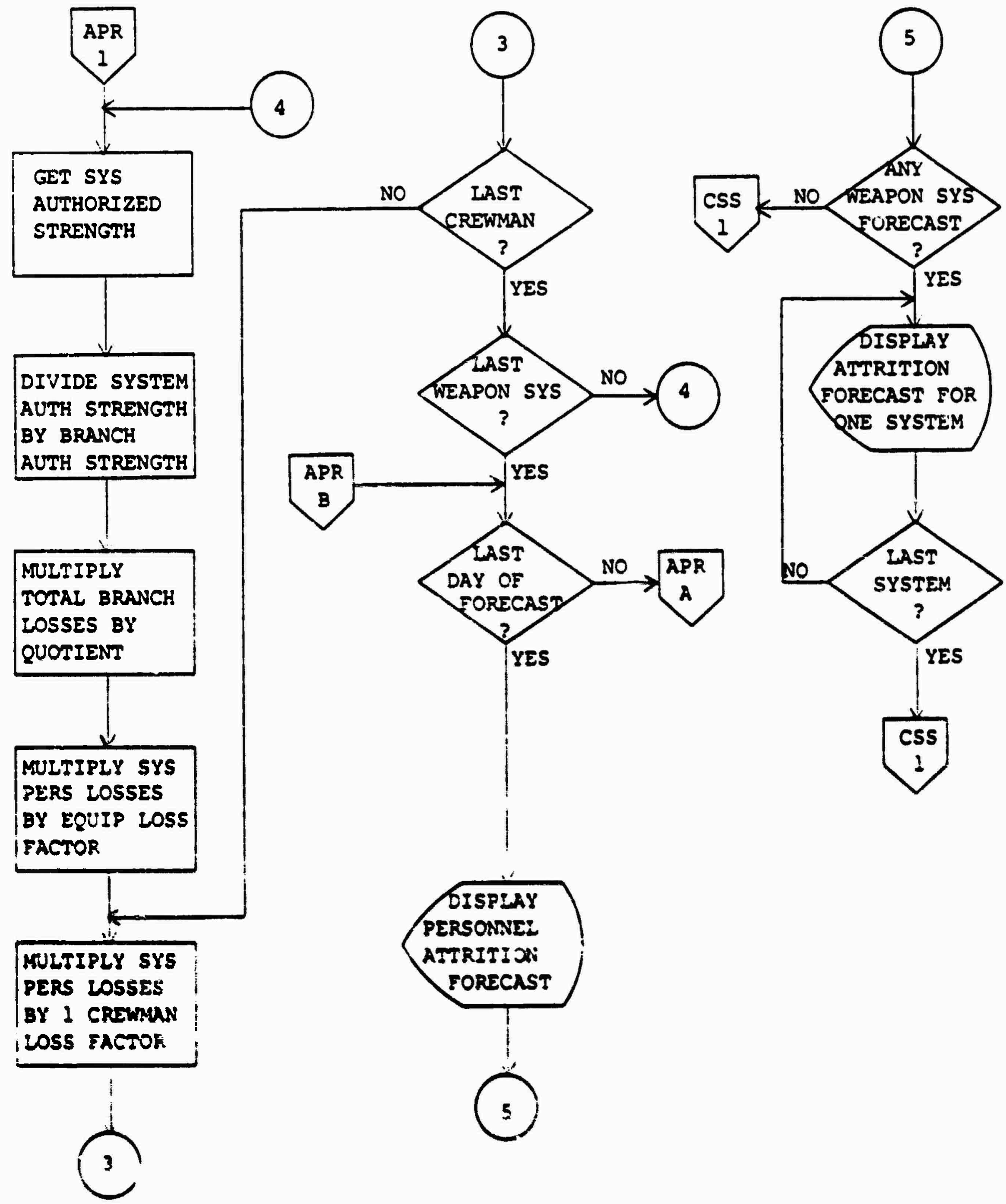


Figure F-6. Continued.

is multiplied by the equipment attrition factor (in the case of the M60A1 and other tanks, this factor is .385). Finally, the number of losses per weapon crew position is obtained by multiplying the number of crewmen losses by each crew position factor (in the case of tanks, the crew position factors are commander: .43, gunner: .28, driver: .16, and loader: .13).

The weapon system procedure is repeated for each designated weapon system. The entire procedure is then repeated for each day of the forecast. SDC assumes that current practice will prevail and that attrition forecasts will be made for no more than 5 days. If longer forecasts are required, software would have to be modified accordingly.

Attrition factors and authorized strengths would be stored in the CSS. Once generated, attrition forecasts would also be stored in the CSS, at least temporarily. To avoid excessive use of file storage, provision would be made for deleting forecasts that are no longer needed. One way to do this would be to repeat mission names. That is, if an operation named ALPHA had been completed and the forecast no longer was useful, then when planning a new forecast, the user could give the new operation the name ALPHA. Then, the software could store the new forecast in the space used by the old.

Data Display

Figure F-7 shows the format of the personnel attrition forecast output display. The format is explained in the figure, below the display. Figure F-8 shows the format of the weapon system attrition forecast output display. Again, the format is explained in the figure, below the display. A similar display would be presented for each of the weapon systems designated by the user.

Organizational Impact

The primary organizational impact of the Attrition Prediction Routine would be to reduce the workload of personnel charged with generating attrition forecasts. However, the G4 would be brought into the attrition prediction business formally, as a result of system forecasting. Information required by the routine either would be loaded at startup, or else would be extracted from existing reports for entry into TOS. Extraction and entry of data would be neither difficult nor time-consuming.

SDC does not anticipate any changes to the existing manual reporting methods. No new reports would be added to the system, and none would be deleted or modified as a result of this routine. Division personnel might be required to print out attrition forecasts to preserve a hard copy record.

```
         1111111111222222222233333333334444444444555555555566666666667777777777 8
1234567890123456789012345678901234567890123456789012345678901234567890123456789 0

PERSONNEL-ATTRITION-FORECAST: 58 MECH DIV                TIME: 78/06/11/0930F

MISSION: ALPHA              TYPE-OF-OPERATION: DEFENSE-OF-POSITION

                     DAY-1     DAY-2     DAY-3     DAY-4     DAY-5     TOTAL
TOTAL-LOSSES       : 301     : 174     : 171     : 169     : 167     : 982
LOSSES-BY-BRANCH
  INFANTRY         : 180     : 101     : 96      : 95      : 95      : 567
  ARTILLERY        : 12      : 9       : 10      : 10      : 10      : 51
  ARMOR            : 65      : 36      : 35      : 34      : 34      : 203
  ENGINEERS        : 11      : 8       : 8       : 8       : 8       : 42
  ALL-OTHERS       : 34      : 22      : 22      : 22      : 20      : 119
```

EXPLANATION

1. The initial line only refers to the reporting division and the date/time group for the forecast.

2. The second line provides the mission name and the type of operation for which the forecast was generated.

3. The remainder of the display is a day-by-day breakout of the expected division losses both by total and by branch. The length of forecast is for 5 days as recommended in FM 101-10-1. A cumulative forecast total is also provided both for the division and each of the primary branches.

4. The italicized areas represent data calculated by the machine and loaded into the pre-formatted output display.

Figure F-7. The Personnel Attrition Forecast Output Display.

```
         111111111122222222223333333333444444444455555555556666666666777777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

WEAPON-SYSTEM-LOSS-FORECAST-FOR: M60A1                        TIME: 78/06/11/0930F

MISSION: ALPHA                          TYPE-OF-OPERATION: DEFENSE-OF-POSITION

UNIT: 58 MECH DIV

                    DAY-1      DAY-2      DAY-3      DAY-4      DAY-5      TOTAL
EQUIPMENT           : 12       : 7        : 7        : 7        : 7        : 40
TOTAL-CREWMEN       : 32       : 18       : 18       : 18       : 18       : 104
  CDR                : 14      :88         : 8        : 8        : 8        : 46
  GNR                : 9       :55         : 5        : 5        : 5        : 29
  DVR                : 5       :33         : 3        : 3        : 3        : 17
  LDR                : 4       : 2         : 2        : 2        : 2        : 12
```

EXPLANATION

1. The initial line indicates the weapon system for which the forecast was generated. One forecast page would be generated for each of the weapon systems requested by the operator. The date/time group is that time specified for the operation.

2. The next two lines provide the mission name, type of operation, and the division for which the request was generated. All basic operator inputs.

3. The remainder of the display is a breakout of equipment by day and the expected total crew losses by day. The crewmen is further sub-divided by individual crewmen by day. Cumulative totals for each category is also provided.

4.. The italicized areas present data calculated by the machine and loaded into the preformatted output display.

Figure F-8. The Weapon System Attrition Forecast Output Display.

Impact on TOS

The Attrition Prediction routine would not conflict with other TOS software. It would neither store data in nor extract data from any TOS file except the CSS. Storage requirements would depend on the number of operations that might be planned simultaneously, and on the number of weapon systems for which forecasts must be made.

Entirely new software would be needed to implement the routine. The new program would have to accept required information from the user and/or extract it from the CSS. It would have to perform the computations indicated in the flow chart shown in Figure F-6. And finally, it would have to store the forecasts in the CSS and output them on the IOD and/or the hard copy printer.

REVISED ATTRITION PREDICTION (RAP)

Revising an attrition forecast on the basis of experience basically requires (1) obtaining data on actual losses, (2) recomputing attrition factors, (3) computing a new forecast for the remaining days of the operation.

Information Requirements

The Revised Attrition Prediction routine requires the following data: (1) mission name; (2) date/time group; (3) the day on which the revised forecast is to begin; (4) the total number of personnel gained on the preceding day; (5) actual numbers of losses per branch on the preceding day; (6) the actual number of crewmen lost to each system on the preceding day; (7) the initial forecast generated by the Attrition Prediction (APR) Routine; (8) division attrition factors for overall losses; and (9) system component names as described above. The latter three items are retrieved from the CSS and TOS provides the date/time group; all other data items are entered by the user. A suggested format for data entry is presented and explained in Figure F-9.

Data Processing

As an example of data processing, consider a division about to start the second day of an operation. Actual losses for Day 1, both by branch and by weapon system, are now known, as are gains for Day 1. These data are entered into the routine as indicated in Figure F-9, along with other required information. The routine first sums branch losses to obtain total losses. This quantity is divided by the division's assigned strength as of Day 1 to obtain an actual attrition factor. Division assigned strength is then computed by adding gains to and then subtracting actual losses from assigned strength as of Day 1.

```
          1111111111222222222233333333334444444444555555555566666666667777777778
 12345678901234567890123456789012345678901234567890123456789012345678901234567890

MISSION-NAME: ALPHA                                       TIME: 78/06/12/0900F

START-REVISED-FORECAST-DAY: 2   ENTER-TOTAL-GAINS-FOR-REVISED-FORECAST: 0

ENTER-BRANCH-LOSSES                           WEAPON-SYSTEM-CREWMEN-LOSSES

  INFANTRY: 276                     : M60A1 : 40          :          :
 ARTILLERY: 7
     ARMOR: 109                     :       :             :          :
 ENGINEERS: 18
ALL OTHERS: 31                      :       :             :          :
```

EXPLANATION

1. The initial line of the input format will be filled in by the operator to indicate the mission to be revised and to show the date/time group of the revised forecast.
2. The second line is used to specify the day the revision is to begin. Total actual division personnel gains are entered to permit the assigned strength to be adjusted.
3. The third line is for inserting branch losses. The sum of the actual branch losses should equal the division's actual total losses. The sum of the actual branch losses will be used in conjunction with the gains to recompute the assigned strength.
4. To generate a weapon system revision, the operator must merely insert the weapon systems to be revised and the total crewmen losses for that system on the revised day. Systems not part of the original forecast will be disregarded.

Figure F-9. The Revised Attrition Prediction (RAP) Input Display.

Next, the routine recognizes that attrition rates typically drop after the first day of an operation, and then level off. It therefore obtains attrition factors from the CSS for Day 1 and succeeding days and forms a ratio, dividing the factor for succeeding days by the factor for Day 1. It multiplies this ratio by the actual attrition factor for Day 1 to obtain an attrition factor for Day 2 and beyond. Then, it multiplies the new assigned strength by the Day 2 attrition factor to obtain the revised estimates of total losses for the second day. It also uses the adjusted Day 2 attrition factor for days 3, 4, and 5.

If the revised forecast is to start after Day 2, a somewhat different procedure is employed. Loss rates typically remain relatively constant for the second and succeeding days, so that the actual attrition rate does not have to be adjusted by a ratio as it was for Day 1. Therefore, the revised prediction factor is merely the preceding day's actual losses divided by that day's assigned strength, and the same factor applies for succeeding days.

Branch losses are computed in a somewhat different way. Actual losses for each branch are divided by actual total losses to obtain a revised factor for each branch. Then this factor is multiplied by total predicted losses to predict branch losses. The same procedure yields a prediction for total weapon crew losses, and then the standard attrition factors are used to obtain predicted equipment and crew position losses.

The above procedures are flow-charted in Figure F-10.

Data Displays

The suggested displays for revised personnel attrition forecast and weapon system attrition forecast outputs are shown in Figures F-11 and F-12, respectively. The revised weapon system forecast output display would be generated once for each weapon system designated by the user.

Organizational Impact

The organizational impact of the Revised Attrition Prediction Routine will depend to some extent on its frequency of use. It should have little or no impact on current reporting methods. Its impact on personnel workload will not be great, since the only demands it imposes are that users extract required information and enter it into TOS. Its major impact is expected to be positive. That is, staff personnel will be able to predict, on the basis of something other than their own experience and hunches, expected losses to personnel and major weapons if an operation continues at its present intensity. SDC personnel found no evidence that this capability exists at present in either of the two FORSCOM divisions they visited.

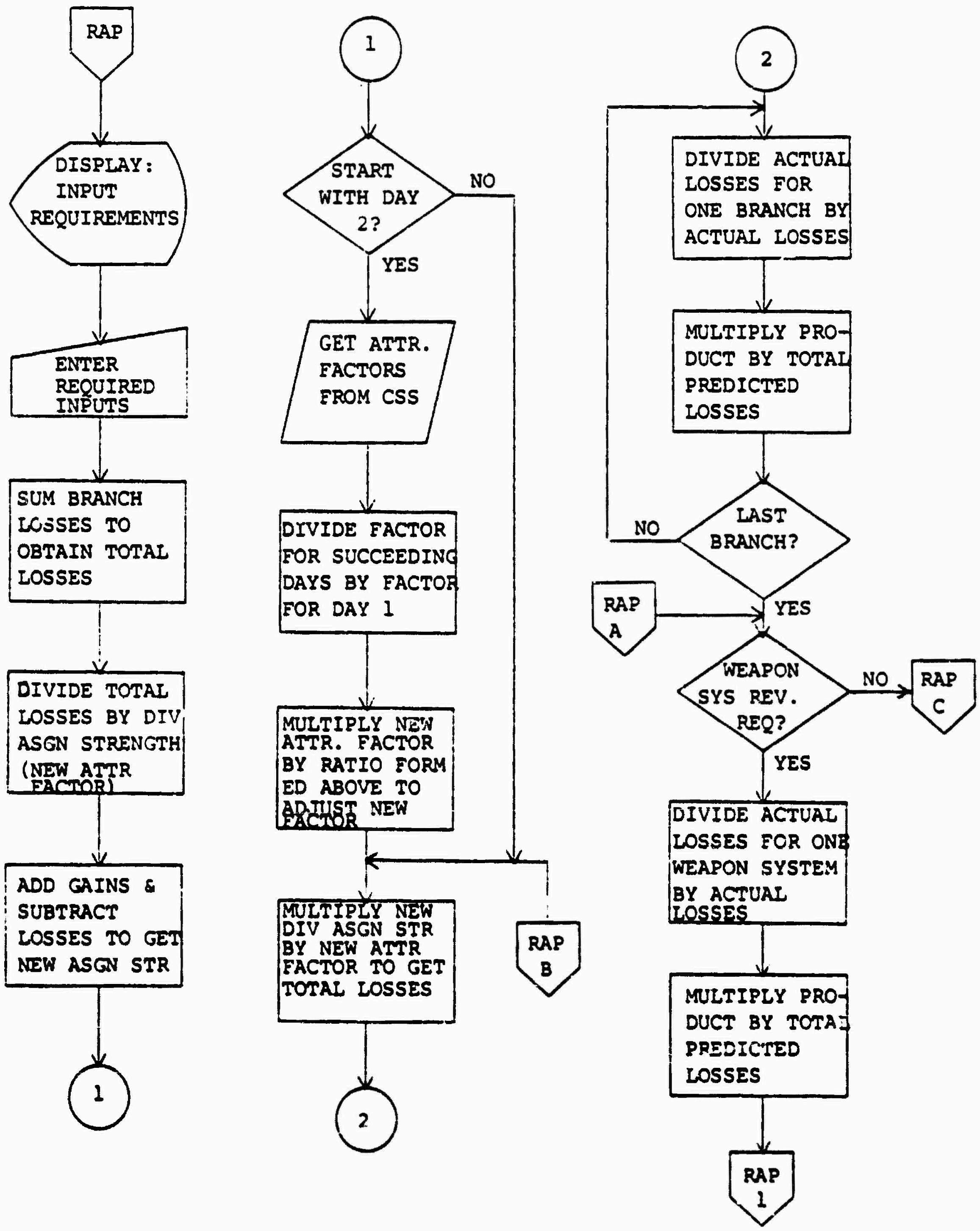


Figure F-10. Simplified flowchart of the RAP routine.

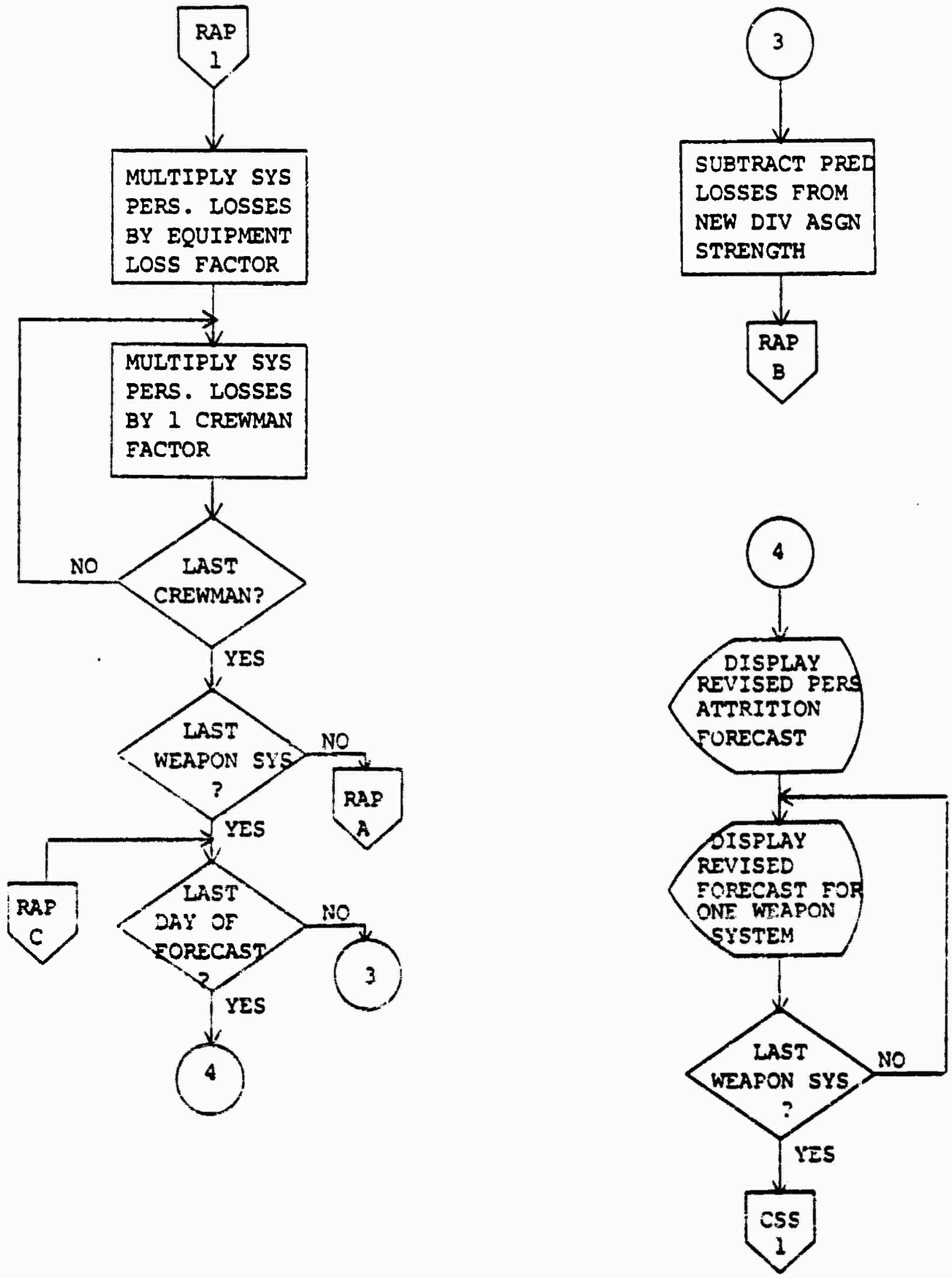


Figure F-10. Continued

```
         11111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

REVISED-PERSONNEL-ATTRITION-FORECAST: *58 MECH DIV* TIME: *78/06/12/0900F*

MISSION: *ALPHA* TYPE-OF-OPERATION: *DEFENSE-OF-POSITION*

	DAY-1	DAY-2	DAY-3	DAY-4	DAY-5	TOTAL
ACTUAL-LOSSES	: 451	: 174	:	:	:	:
ORIGINAL-FORECAST	: 301	: 174	: 171	: 169	: 167	: 982
REVISED-FORECAST	: 451	: 258	: 253	: 248	: 243	: 1453
INFANTRY	: 276	: 158	: 155	: 152	: 149	: 890
ARTILLERY	: 17	: 10	: 9	: 9	: 9	: 54
ARMOR	: 109	: 62	: 61	: 60	: 59	: 351
ENGINEERS	: 18	: 11	: 10	: 10	: 10	: 59
ALL-OTHERS	: 31	: 17	: 17	: 17	: 17	: 99

EXPLANATION

1. The first two lines of the display are reported data from the original forecast indicating who the forecast is for, mission name, and the type of operation. Time represents the revised time.

2. The remainder of the display is a re-generation of the forecast using data applied by the operator via the revision forecast input format. In the example shown above, the operator has chosen to revise the forecast starting with day 1. The remaining days present a new forecast using the operator data and the procedure provided in the report.

3. The only way possible for the operator to compare the original and revised forecasts is to print both and compare off-line.

Figure F-11. The Revised Personnel Attrition Prediction Output Display.

```
         11111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

REVISED-WEAPON-SYSTEM-ATTRITION-FORECAST-FOR: M60 TANK  TIME: 78/06/12/0900F

MISSION: ALPHA                  TYPE-OF-OPERATION: DEFENSE-OF-POSITION

UNIT: 58 MECH DIV

                    DAY-1     DAY-2     DAY-3     DAY-4     DAY-5     TOTAL
EQUIPMENT           : 17      : 9       : 9       : 8       : 8       : 51
TOTAL-CREWMEN       : 40      : 23      : 23      : 22      : 22      : 130
  CDR                 : 17      : 10      : 10      : 9       : 9       : 55
  GNR                 : 11      : 6       : 6       : 6       : 6       : 35
  DVR                 : 6       : 4       : 4       : 4       : 4       : 22
  LDR                 : 6       : 3       : 3       : 3       : 3       : 18
```

EXPLANATION

1. As with personnel forecast, the initial lines of data merely define this as a revision to the organized forecast and state the system, date/time group, mission name, types of operation, and the division for which it was done.

2. The remainder of the display is a duplicate of the original but updated using the operator entered data and the procedure described in the report.

3. Comparing this forecast with the original must also be done off-line.

Figure F-12. The Revised Weapon System Attrition Prediction Output Display.

Impact on TOS

The routine's impact on TOS, like its organizational impact, will depend in part on its frequency of use. In other respects, its impact on TOS is expected to be approximately equal to that of its conceptual parent, the Attrition Prediction Routine.

WEAPON SYSTEM STATUS REPORTING (WSS)

Though the Weapon System Status Reporting Routine is not necessarily more important than the routines described above, it promises to demand more attention, to be used more often, to have greater organizational impact, and to have greater impact on TOS than any of the other routines comprising the proposed application.

Information Requirements

The Weapon System Status Reporting Routine requires a large number of constant information items, their exact number depending on commanders' guidance regarding the weapon (and perhaps tactical support) systems to be reported via the routine. For each such system, the name of each major component must be available. For example, if status is to be maintained for M60A1, then the names "EQUIP," "CDR," "GNR," "DVR," AND "LDR" would be required. These component names, it may be recalled would also be needed for the Attrition Prediction (APR) and Revised Attrition Prediction (RAP) routines, and presumably would be loaded at system startup. At the same time, the Weapon System Status Reporting routine requires the number authorized for each component of each system, and the unit identification of each unit at the lowest echelon to be reported. These are relatively constant data items, and thus would probably also be loaded at system startup.

The above items of information would all be used in one or another formatted displays. In addition, they would serve to define a matrix in the CSS into which data on system status would be stored. Though such a matrix might take any of a number of forms, one possibility is illustrated in Table F-1. The example shows part of only one system, but all reported systems would be included in the matrix, of course, The example also shows only units in maneuver battalions, and only to the level of companies. However, every unit required to report weapon (and perhaps support) system status via this routine would appear in the list, at whatever level may be designated as the lowest reported echelon. The resulting matrix would accomodate all the data required by the routine, including the following variable data.

The routine requires for each equipment component the number available (on-hand), broken down into numbers operationally ready and in maintenance or repair, and

TABLE F-1. AN EXAMPLE OF A MATRIX FOR STORING DATA ON WEAPON SYSTEM STATUS ORGANIZED BY WEAPON SYSTEM COMPONENT AND THE LOWEST ECHELON REPORTED.

M60A1

	EQUIP				CDR			GNR			DVR		
	AUTH	AVAIL	MAINT	DEST	AUTH	AVAIL	LOST	AUTH	AVAIL	LOST	AUTH	AVAIL	LOST
HHC/1-49													
A/1-49	17	10	2	5	17	15	2	17	17	0	17	13	4
B/1-49													
C/1-49													
CSPT/1-49													
HHC/1-66													
A/1-66													
B/1-66													
C/1-66													
CSPT/1-34													
HHC/3-115													
A/3-115													
B/3-115													
C/3-115													

the number lost. Since equipment may be in maintenance or repair any time from a few minutes to a few months (or longer, according to some subject matter experts and experimental participants), a criterion may be needed such as exists today in at least some divisions. That is, if an equipment will not be op-ready within 12 (or 24, or 48, or 96) hours, it should be entered as lost.

For each personnel component (i.e., crew position), the routine requires the number of personnel available (present for duty) and the number lost.

A suggested format for entering variable system status data is presented and explained in Figure F-13. After the unit identification and date/time group are entered, the user enters the identification of the system whose status he wishes to enter. At this point, the computer locates the number of systems authorized and the system's component names, and fills them in automatically. The user then enters his data. Immediately after start up, the variable portion of the display would be blank and the user would have to enter virtually all variable data. Thereafter, data stored in the CSS matrix would be displayed automatically after the user entered the unit and system. The user would then merely enter changes to bring the data up to date.

Data Processing

Data processing requirements for the Weapon System Status Reporting routine are relatively straightforward. Software will be needed to accept inputs as described above and store them in the CSS matrix. Of course, the software must also output the data in suitable display formats. In addition, it must be able to roll up data from the echelon stored in the matrix to any higher echelon including division. The roll up routines should be applicable to task forces as well as battalions, and perhaps to company teams as well as companies. This requirement implies access to the Unit Task Organization (UTO) file to determine unit subordination.

The software must be able to compare numbers of available components within a weapon system--both within a unit and across units--first to determine numbers of operationally ready systems, and then to determine component shortages and excesses (see "Data Displays," below). It must also compute percentages of components available (on hand or present for duty) and/or operationally ready, and of systems operationally ready. The definition for "operationally ready" depends on commanders' guidance; for the examples described below, the arbitrary definition was a "ready to fight" tank, fueled and armed, plus a full crew.

Finally, query and SRI capability should be included. Many, and perhaps most, output requirements will be satisfied by the formatted displays described below. Nonetheless, a user may wish to extract data from the CSS matrix that is not easily available using those displays. For example, he may need to determine the total number of crewmen either present for duty or lost for a

```
         111111111122222222223333333333444444444455555555556666666666777777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

UNIT: A/1-49                    TIME: 78/06/11/0930F

SYSTEM: M60A1              AUTH: 17

COMPONENT     AVAIL     OP-RDY     MAINT     LOST

EQUIP         : 16      : 15       : 1       : 1

CDR           : 17      :          :         :

GNR           : 17      :          :         :

DVR           : 17      :          :         :

LDR           : 16      :          :         : 1
```

<u>EXPLANATION</u>

1. The only entries required of the operator are the five system components shown in the example. This data would normally be provided by the company XO via the Admin/Log Net.

2. It must be assumed that the data provided by the XO has been load balanced by the company CO before transmission. Any other manipulation of the data would be by SOP.

Figure F-13. The Weapon System Status Reporting (WSS) Input Display.

specified system. Such data might be needed for a commander's briefing or in response to a commander's query. Or the user might need to query the data base while preparing a combat service support annex to an operations plan. A simplified flowchart of the routine is presented in Figure F-14. A weapon system status "menu" appears in Figure F-15 to be used in selecting displays.

Data Display

Three formatted output displays are suggested for the Weapon System Status Reporting routine.

Unit/System Status Report. This display provides the status in detail of one type of weapon (or perhaps support) system for one specified unit. The display is suitable for virtually any tactically important system, and could show the status of all that system's components for any echelon from division down to an individual system.

The Unit/System Status Report is modelled after the Weapon System Status Report (WESS) that is part of the Weapon System Replacement Operation concept mentioned earlier. The relationship of the two reports and the concept's relevance to the application proposed here are discussed below, under "Organizational Impact" and "Impact on TOS." The suggested format of the Unit/System Status Report appears and is explained in Figure F-16.

Unit Weapon System Summary. This display provides a summary of the status of components of a selected system. It presents the summary for a specified unit, breaking it down by subordinate units at the next lower echelon. Figure F-17 shows a Unit Weapon System Summary of M60A1 systems for a hypothetical battalion, the 2nd of the 29th Armor and its companies. The top half of the display shows for each component the number available (on hand or present for duty) to each company. Thus, the user can determine quickly the companies (and components) most in need of replacements. Meanwhile, the bottom half of the display provides information to assist in cross-leveling or force balancing to maximize the number of operational systems until replacements arrive. This portion of the display shows system shortages and excesses--not in relation to the TOE, but instead in relation to the component currently in shortest supply. For this example, the comparison with the component in shortest supply is dictated by the definition of an operationally ready system as a weapon plus its full crew. If a tank and three-man crew were accepted as an op-ready system, then the comparison would be with the component in next shortest supply.

System Status Summary. Project personnel hypothesized that unit commanders might wish to survey all the weapon systems assigned to their own or subordinate units. The System Status Summary serves this purpose. It may be generated for any unit at any echelon. Its format is illustrated for a single company in Figure F-18. Although the figure shows only four systems, the display can be used for any number of systems, limited only by the capacity of the display device. The display can present a status summary for any unit at any echelon.

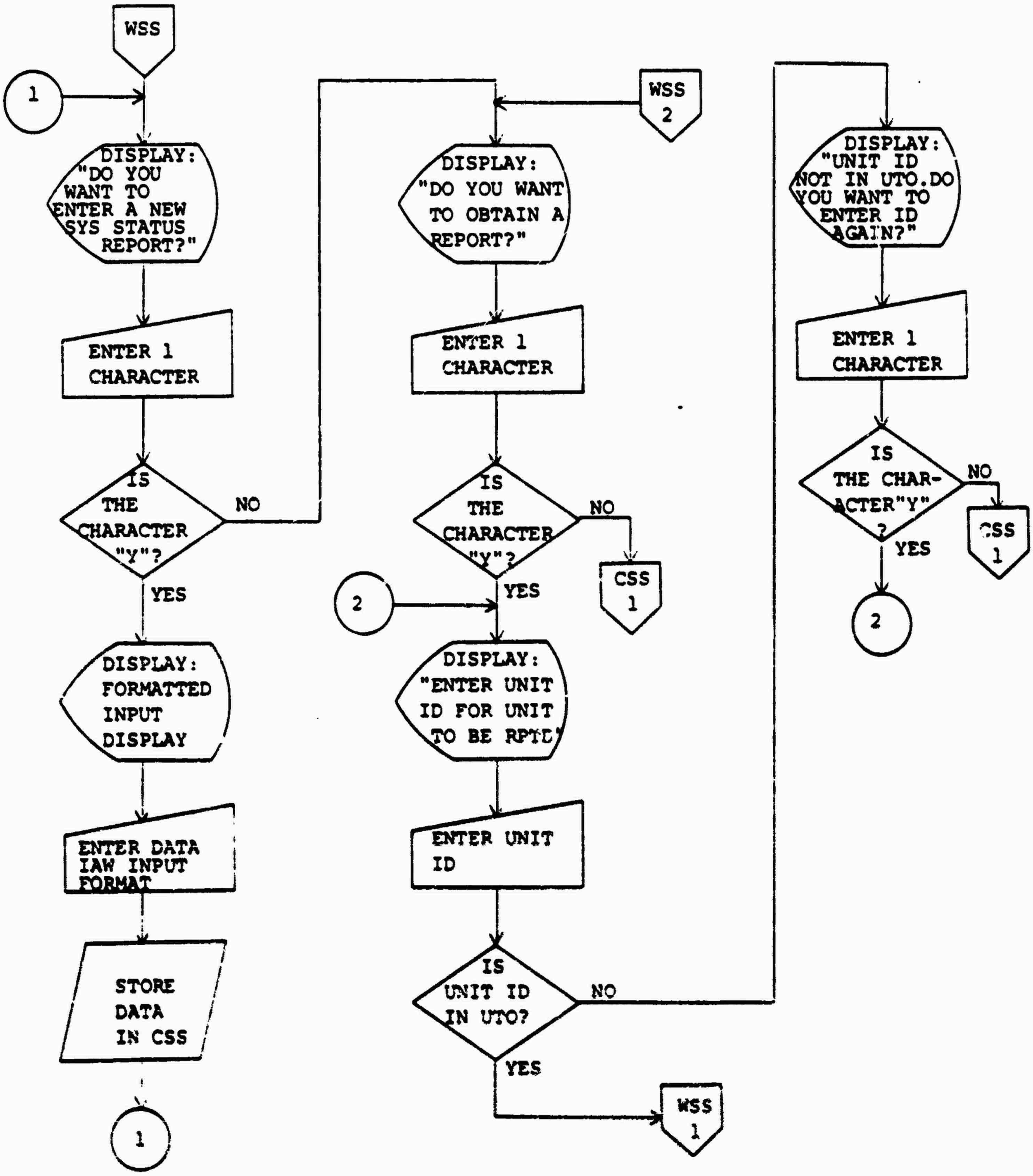


Figure F-14. Simplified flowchart of the WSS routine.

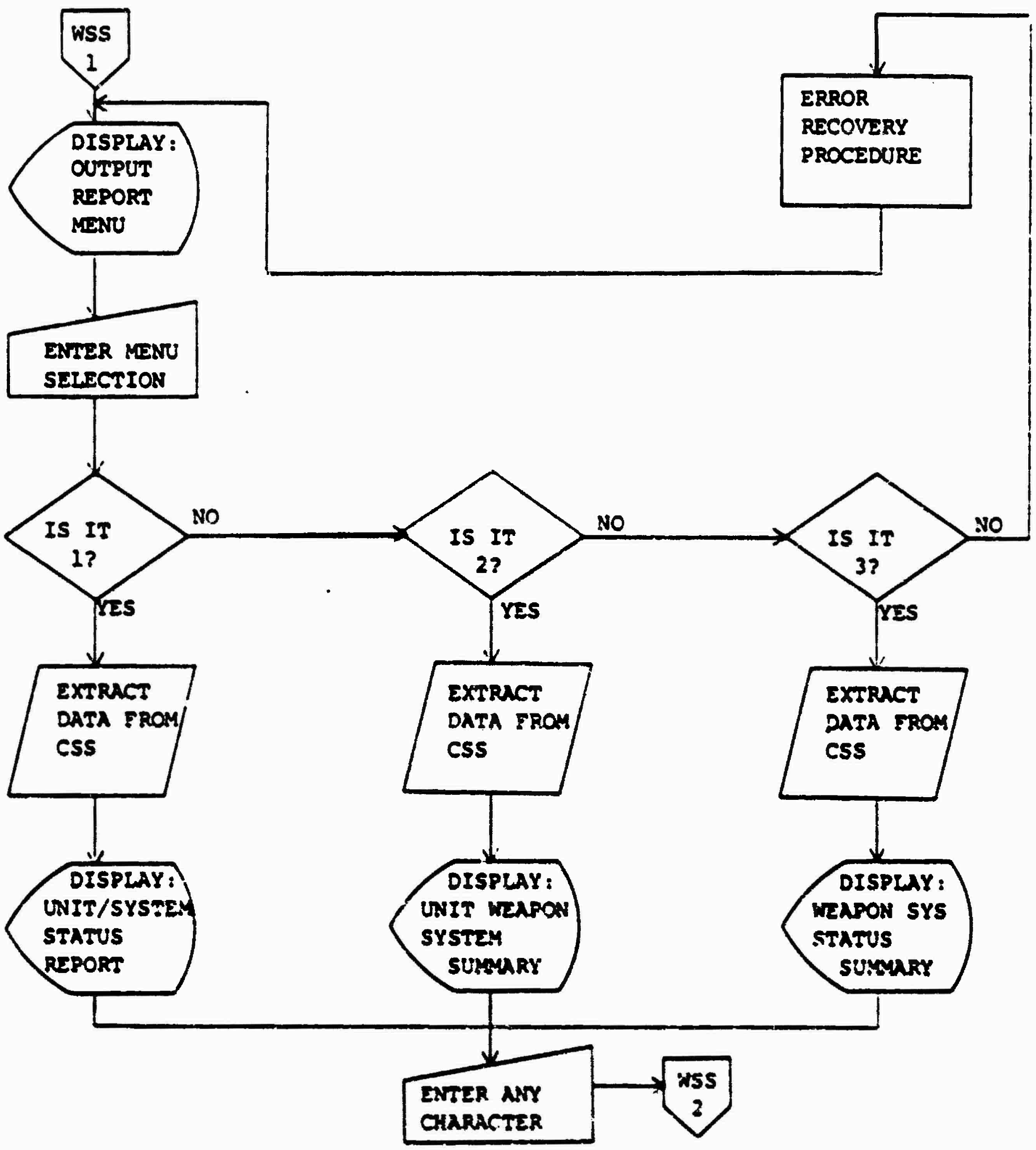


Figure F-14. Continued.

```
         1111111111222222222233333333334444444444555555555566666666667777777778
1234567890123456789012345678901234567890123456789012345678901234567890123456789 0
```

```
ENTER THE NUMBER OF THE REPORT YOU WANT:

    1.  UNIT/SYSTEM STATUS
    2.  UNIT WEAPON SYSTEM SUMMARY
    3.  WEAPON SYSTEM STATUS SUMMARY
    4.  EXIT FROM WSS ROUTINE
```

Figure F-15. The Weapon System Status menu.

```
         111111111122222222223333333333444444444455555555556666666666777777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

STATUS-OF: M60A1              FOR: A/1-49                TIME: 78/06/11/0930F

SYSTEM-AUTH: 17    OP-RDY: 10    SHORTAGE: 7      %-OP-RDY: 58

COMPONENT   TOE      OP-RDY   %-OP-RDY   DEST   SYS-SHORT   SYS-EXCESS   MAINT

EQUIP       : 17     : 10     : 58       : 5    : 3         :            : 2

  CDR       : 17     : 15     : 88       : 2    :           : 5          :

  GNR       : 17     : 17     : 100      :      :           :            :

  DVR       : 17     : 13     : 76       : 4    :           : 3          :

  LDR       : 17     : 17     : 100      :      :           : 7          :
```

EXPLANATION

1. Line 1 provides the requestor with information on the system and unit requested. The date/time group will indicate the last recorded update in the file for the unit and system specified.

2. Line 2 is a system line to provide the requestor with recapitulation of the unit's status for the system. In the example provided, the number of systems authorized (17) is self explanatory, the number of OP-RDY systems (10) is equal to the lowest number of system components available (EQUIP or any of the crew components), the shortage of systems (7) is equal to the number of unavailable systems through loss and maintenance (5 destroyed and 2 maintenance), and the % OP-RDY is self explanatory.

3. Line 3 is basically a summary of availability for each of the system components. Only the columns headed SYS-SHORT and SYS-EXCESS require explanation. The column SYS-SHORT provides the requestor with the system component which is in shortest supply, in this case the EQUIP. The numerical indicator presented (3) is intended to reflect the difference between the component in shortest supply and the component in next shortest supply, in this case DRIVERS. This data is intended to assist log and admin personnel in identifying components, either people or equipment, which are necessary to reconstitute and provide more tactical systems to the commander. The SYS-EXCESS column is provided to assist log, admin and more specifically the Weapon System Manager in identifying system components which might be considered excess and potentially useful in reconstituting or load balancing other units. The data presented 5-CMDRS, 7-GUNNERS, 3-DRIVERS, and 7-LOADERS represent the comparative difference between the component in shortest supply (EQUIP-10) and the other components. This data could be summarized and presented to the operations types and/or commander for decision making.

4. The data could be presented for any echelon desired.

5. The italicized values represent data calculated by the machine.

Figure F-16. The Unit/System Status Report.

```
          11111111112222222222333333333344444444445555555555666666666677777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

STATUS-OF: M60A1 FOR: 2-29 TIME: 78/06/11/0930F

UNIT	EQUIP	CDR	GNR	DVR	LDR
HHC/2-29	: 3	: 3	: 3	: 3	: 3
A/2-29	: 15	: 14	: 16	: 16	: 15
B/2-29	: 17	: 17	: 17	: 17	: 17
C/2-29	: 15	: 17	: 16	: 16	: 17
SYSTEM SHORT/EXCESS					
HHC/2-29	:	:	:	:	:
A/2-29	: +1	:-1	: +2	: +2	: +1
B/2-29	:	:	:	:	:
C/2-29	:-1	:+2	: +1	: +1	: +2

EXPLANATION

1. Line 1 represents the system and echelon requested. The date/time group reflects the time of the request and hence the data base at that time. It is anticipated that this summary could be reported by battalion, brigade, or division.

2. Line 2 and below is a summary by company of all the component data entered into the data base for each of the companies. It permits the requestor to rapidly scan the component data for each of the reporting companies. The sample shown is a battalion summary organized by company, the brigade summary would show all assigned battalions with each of its components summed for comparison, and the division summary would be presented by brigade with each of its components summed for comparison. The display appears to have more utility at the battalion and brigade level to assist log, admin and the Weapon System Manager in addressing replacement and load balancing responsibilities.

3. The line titled SYSTEM SHORT/EXCESS is provided to aid the user in identifying the imbalance between components. The lowest component in a line is used as the point of reference and reflected as a negative value, all other components are indicated as positive numbers and are equal to the difference between the two.

4. The italicized values represent data calculated by the machine or values entered by the user in calling up the display.

Figure F-17. The Unit Weapon System Summary.

```
          111111111122222222223333333333444444444455555555556666666666777777777778
12345678901234567890123456789012345678901234567890123456789012345678901234567890

STATUS-SUMMARY-FOR: A/1-49                        TIME: 78/06/11/0930F

              SYS       EQUIP     CREWS     SYS       STATUS
SYSTEM        AUTH      AVAIL     AVAIL     AVAIL     %-OP-RDY

: M60A1       : 17      : 10      : 13      : 10      : 58

: M113A1      : 1       : 1       : 0       : 0       : 0

: M222        : 2       : 1       : 2       : 1       : 50

: M88         : 1       : 1       : 1       : 1       : 100
```

EXPLANATION

1. Line 1 indicates the organization for which the summary was requested. The date/time group indicates the time of the request and the data base at that time.

2. Line 2 and below is intended to present a summary of reported systems for the organization requested. In this company example, the company has reported status on four weapon systems: Tank, APC, DRAGON, and a Recovery Vehicle. Presumably these items were required by SOP or directed by the commander. A similar display could be requested for a battalion, brigade, or division. In higher echelon requests, the systems displayed would reflect the data base and be rolled up to represent the numbers authorized by task organization.

3. The display is intended to provide the requestor an overall status of systems for a given echelon. It has utility for log and admin personnel in monitoring the overall weapon system capability of a given unit or echelon. It may also provide a significant input to the G3 for determining combat efficiency or power.

4. The italicized values represent data calculated by the machine or entered by the user in calling up the display.

Figure F-18. The Weapon System Status Summary.

Organizational Impact

The Weapon System Status Reporting routine has the greatest organizational impact of any routine in the proposed application. First, it promises to enhance greatly the timeliness and accuracy of status reporting. Entry into TOS eliminates the necessity for at least some of the personnel in the reporting chain to handle the data and thereby eliminates some of the sources of error in the data. The disadvantages of sequential reporting and the benefits of eliminating such reporting to whatever extent is possible have been discussed earlier in this report under "General Considerations," and need no repetition here. Similarly, the implications of reporting at the data source for the principle of hierarchical review have been discussed, along with the consequences to the S1 and S4 at both brigade and battalion levels if a TOS terminal is not located at the trains for each echelon. Suffice it to say, then, that each of these factors must be weighed in considering this portion of the proposed application.

The routine also promises to assist admin/log personnel in their tasks of monitoring the status of personnel and equipment when units are task organized, tasks which currently create problems for the G1 and G4, provided that data are collected and maintained at a sufficiently low level.

An important aspect of the organizational impact of the Weapon System Status Reporting routine is its relationship to the Weapon System Replacement Operations concept. The Weapon System Replacement Operations (WSRO) concept, an innovation which the Army is in the process of implementing, responds to a need found within the two FORSCOM divisions surveyed in this effort. The need is a method of overcoming the problems inherent in dual chain reporting in administration and logistics data. WSRO consists of five components designed to overcome such problems. These are:

(1) "Shelf requisitions" would be prepared for both personnel and equipment, to be filled immediately upon mobilization.

(2) CONUS to corps transport of personnel and equipment would be accomplished in the most expeditious manner possible, in accordance with theater army fill priorities.

(3) Personnel and equipment would be linked up at Corps to form weapon systems, which would then be dispatched to divisions. There is provision in the concept for sending replacement components when necessary; however, the emphasis is on delivering to the divisions complete, ready to fight systems. The divisions would retain the flexibility to reconfigure weapons and personnel as necessary; indeed, the concept would allow them to manage by exception, rather than having to assemble separate components themselves. The same is true at battalion level. The battalion commander has the flexibility to

reconfigure if he wishes, for example, to mix experienced and inexperienced personnel in each crew. But he, too, can manage by exception instead of having to assemble systems from separate components while simultaneously directing a battalion during an operation.

(4) The Weapon System Summary Report (WESS) is the key information tool for the concept. It provides the Weapon System Manager with the data he needs to allocate resources in accordance with commanders' guidance.

(5) The Weapon System Manager, under the concept, will be a full-time position in corps and division staffs and an additional duty for admin/log personnel at brigade and battalion. The Weapon System Manager's responsibility is to allocate resources in accordance with commanders' guidance, information in the WESS, and available systems and personnel and equipment components.

The Weapon System Replacement Operations concept will have a considerable impact on the admin/log organization within a division, because it requires joint reporting of personnel and equipment components of weapon systems. Joint reporting in this manner is a departure from the normal reporting system, in which admin personnel are exclusively concerned with personnel issues and logistics personnel are exclusively concerned with logistics issues. While reinforcing and enhancing the tendency for administration and logistics personnel to work together, Weapon System Replacement Operations should also tend to narrow the gap between the two sections of the command staff.

In its efforts to improve logistics status reporting, SDC personnel ensured that Weapon System Status Reporting Routine would be compatible with the WSRO concept. Therefore, the organizational impact of the routine is essentially the same as the status monitoring elements of that concept, in terms of the above considerations.

However, there is another organizational impact of both Weapon System Replacement Operations and the Weapon System Status Reporting routine, and that is in respect to the number of systems reported. Weapon System Replacement Operations encompasses only four systems: the tank, the TOW, the advanced attack helicopter, and the improved HAWK. Discussions with personnel at the two FORSCOM divisions and with subject matter experts yielded data inconsistent with this selection, as is evident from inspecting Table F-2. Since commanders' guidance differ with respect to which systems should be reported, reporting requirements are likely to continue to vary from one organization to the next.

Finally, there is the validation aspect of the Weapon System Status Reporting routine. Data entered into the TOS regarding losses of personnel and equipment can be compared with projected losses from the Attrition and Revised Attrition Prediction routines to determine their accuracy. Over a period of time, division personnel could use the results of these comparisons to adjust the prediction models.

TABLE F-2. ARMY WEAPON SYSTEMS FOR WHICH STATUS RECORDS ARE MAINTAINED OR FOR WHICH SUBJECT MATTER EXPERTS STATED SUCH RECORDS SHOULD BE MAINTAINED.

SYSTEM	FORSCOM DIV #1	FORSCOM DIV #2	SUBJECT MATTER EXPERT #2	SUBJECT MATTER EXPERT #1
M60 (combat tank)	X	X	X	X
M113 (carrier personnel)	X	X	X	X
M106 (carrier, 102mm mortar)	X	X		X
M88 (recovery vehicle, full tracked)	X	X		
M577 (carrier command post)	X	X		
M578 (recovery vehicle full tracked)	X			
DRAGON (guided missile)	X	X	X	X
TOW (guided missle)	X	X	X	X
M151 (truck, utility 4 x 4)		X		
M561 (truck, cargo 6 x 6)		X		
M35A2 (truck, cargo 6 x 6)		X		
M520 (truck, 8 ton)		X		
M599 (truck, fuel servicing)		X		
M54A2 (truck, 5 ton)		X		

X = Status records are maintained, or should be maintained in the opinion of a subject matter expert.

Impact on TOS

The impact on TOS of the Weapon System Status Reporting routine will depend in part on the number of systems that commanders direct for tactical recording. Table F-2 shows that in one division surveyed, as many as 13 systems are considered tactically important, including some support systems. Should this application be implemented, a decision will be necessary as to how much CSS file space should be provided for system status data, or the maximum number of systems that will be accomodated at any given time. The level for which data are reported also has implications for storage requirements, because the echelon to be reported determines the number of units to be accomodated. Ideally, for reasons discussed above, data would be reported for units at the lowest level maintained in the UTO.

The Weapon System Status Reporting routine does not store data in any TOS file except the CSS. If roll up for combined arms units is to be performed, then the routine will need to extract unit subordination data from the UTO. Additionally, the Battlefield Information Report (BIR) file may be able to use data from the CSS.

The BIR is an information tool of the unit commander, used to report his assessment of the battlefield situation to higher echelons. As such, it contains information about the status of selected weapon systems. The formatted output displays of the Weapon System Status Reporting routine may appear to duplicate this information. However, the information on these displays is more detailed than that available on the BIR. Further, it is intended for a different purpose: while the BIR supports the commander directly, this routine's displays support him indirectly, by supporting admin/log personnel in the performance of their duties. Finally, according to subject matter experts, information about weapon systems status is obtained from admin/log personnel. That information, of course, is subject to the problems inherent in the manual methods.

The Weapon System Status Reporting routine can assist in this regard. In preparing the BIR, a user could query the CSS for the required weapon system status information. Alternatively, the user could ignore the weapon system status portion of the report. When he had completed the remaining items of information, he could signal TOS. A TOS software routine could them extract the required information from the CSS, insert it into the BIR, and then transmit the BIR to its destination (including the BIR file).

APPENDIX G

ACRONYMS AND ABBREVIATIONS

ACRONYMS AND ABBREVIATIONS

ADC	Air Defense Command
Admin	Administration
ADMINCEN	Administration Center
ADP	Automatic Data Processing
AG	Adjutant General
APC	Armored Personnel Carrier
APR	Attrition Prediction Routine
ARI	Army Research Institute
ASAP	As-soon-as-possible
ASGN	Assign
ASP	Ammunition Supply Plant
AUTH	Authorized
Bde	Brigade
BIR	Battlefield Information Report
Bn	Battalion
CACDA	Combined Arms Combat Development Activity
CAMMS	Computer Assisted Map Maneuver System
CATRADA	Combined Arms Training Developments Activity
CATTS	Combined Arms Tactical Training Simulator
CDR	Commander
CGSC	Command and General Staff College
CMD	Command
CMDR	Commander
CM&D	Collection Management and Dissemination
CO	Commander
CONUS	Continental United States
conv	conventional
CRIT SHORT	Critical shortage
CRT	Cathode Ray Tube
CSS	Combat Service Support
DA	Department of the Army
df	degrees of freedom
DISCOM	Division Support Command
DIV	Division
DIVARTY	Division Artillery
DIVWAG	Division War Games
D/L	Distribution Lists
DMMC	Division Material Management Center
DVR	Driver

Enl	Enlisted
EOB	Enemy Order of Battle
Equip	Equipment
ESD	Enemy Situation Data
F	F-Ratio
FORSCOM	United Stated Army Forces Command
FSE	Fire Support Element
G1	Assistant Chief of Staff - Personnel
G2	Assistant Chief of Staff - Intelligence
G3	Assistant Chief of Staff - Operations
G4	Assistant Chief of Staff - Logistics
GNR	Gunner
HHC	Headquarters and Headquarters Company
HQ	Headquarters
ICM	Intelligence Collection Management
IOD	Input Output Device
KIA	Killed In Action
LDR	Loader
LOG	Logistics
LOGCEN	Logistics Center
[illegible]	Manual
[illegible]	Missing in Action
[illegible]	Military Occupational Specialty
[illegible]	Mean Square
[illegible]	Named Area of Interest
NBC	Nuclear, Biological, Chemical
NCOIC	Noncommissioned Officer in Charge
OFF	Officer
OP-RDY	Operationally Ready
OPS	Operations
OR	Operations Research
PDS	Personnel Daily Summary
PERSCOMEUR	Personnel Command, Europe
PERSREP	Personnel Report
PLRS	Position Location and Reporting System
POL	Petroleum, Oils and Lubricants

PRED	Prediction
PSR	Personnel Strength Report
PW	Prisoner of War
RAP	Revised Attrition Prediction
RATT	Radio Teletype
RED CON	Readiness Condition
R&S	Reconnaissance and Surveillance
S1	Adjutant
S3	Operations and Training Officer
S4	Supply Officer
SDC	System Development Corporation
SOP	Standing Operating Procedure
SRI	Standing Request for Information
SS	Sum of Squares
SSSI	Special Status of Selected Items
STAT	Status
SWF	Staff Working File
TA	TOS Assisted
TACFIRE	Tactical Fire Direction System
TER	Terrain File
TF	Task Force
TOE	Table of Organization and Equipment
TOC	Tactical Operations Center
TOS	Tactical Operations System
TOW	Tactical Operations Weapon
TMO	TOS Managers Office
TRADOC	United States Army Training and Doctrine Command
TS	TOS Supported
TSM	TOS System Manager
UTD	Unit Tactical Disposition File
UTO	Unit Task Organization File
WESS	Weapon System Status Report
WIA	Wounded In Action
WO	Warrant Officer
WSS	Weapons System Status Reporting
XO	Executive Officer