

Research Report 1238

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INTEGRATED PERSONNEL AND TRAINING INFORMATION FOR TRADOC SYSTEM MANAGERS (TSM): TECHNOLOGICAL GAPS

C. Dennis Fink and William A. Carswell
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Most of the technological gaps related to deficiencies in procedures for estimating training and personnel requirements, and for the development of training strategies, during Phases I and II of the Army's Life Cycle System Management Model (LCSMM). Specifically, there was found to be an absence of satisfactory techniques for (a) deducing training and personnel requirements from materiel characteristics; (b) identifying excessive human resources demands stemming from materiel concepts; (c) identifying functions most appropriately performed by equipment, by persons, or by a man-machine combination; (d) generating task analytic data during Phase I of the LCSMM; (e) identifying high-risk training tasks during Phase I of the LCSMM; (f) indicating appropriate training strategies before actual hardware is developed; and (g) describing human resources data/requirements/constraints in terms that are meaningful to design engineers. *C*

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Research Report 1238

INTEGRATED PERSONNEL AND TRAINING INFORMATION FOR TRADOC SYSTEM MANAGERS (TSM): TECHNOLOGICAL GAPS

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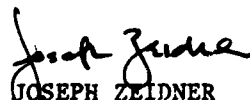
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FOREWORD

The Life Cycle System Management Model (LCSMM) outlines an orderly series of steps that must be accomplished by all sponsor and contractor organizations involved with the development of new Army materiel systems. TRADOC Regulation 600-4 outlines the Integrated Personnel Support (IPS) process for integrating personnel and training considerations into the development effort for new materiel systems. This report identifies and describes the major missing information sources and procedures that are needed for accomplishing the purposes of the IPS process. The data for this report were obtained from an extensive review of civilian and military publications and from structured interviews with TRADOC systems managers (TSMs), their staffs, and related personnel.

This research is part of ARI's 6.3 program and was accomplished under Army Project 2Q763743A771. It is responsive to HRN 78-72 entitled: "Simulation and Training Equipment Planning Sources (STEPS) Requirements for Weapon System Development." This HRN was submitted by COL John W. Swaren, Jr., Deputy Commander, Developing Systems Training and Devices Directorate, U.S. Army Training Support Center (TRADOC), Fort Eustis, Virginia. The advice and support of COL Swaren and his staff were instrumental to the successful completion of this research. The efforts of Ms. Barbara Mroczkowski, who served as COL Swaren's point of contact, were especially helpful in completing this project.

This report will be of particular interest to all those who are planning or conducting research and/or development efforts related to the LCSMM or IPS process.


JOSEPH ZEIDNER
Technical Director

Integrated Personnel and Training Information
for TRADOC System Managers (TSM): Technological Gaps

BRIEF

Purpose:

The Life Cycle System Management Model (LCSMM) outlines an orderly series of steps that must be accomplished by all sponsor and contractor organizations involved with the development of new materiel systems. The Integrated Personnel Support (IPS) model outlines the procedures that should be followed during the development of personnel and training subsystems to comply with the LCSMM. This report identifies some of the technological problems that must be solved to facilitate the application of the IPS model.

Procedure:

The technological problems or gaps reported on were identified during an extensive literature review for, and subsequent development of, a handbook for TRADOC System Managers (TSM), and through interviews with TSMs and their staffs. The handbook describes information sources and technical procedures related to each of the IPS model events discussed in TRADOC Regulation 600-4, Integrated Personnel Support. Where possible technical sources of information that described how to accomplish each IPS event are included. When satisfactory documentation could not be found, a technological gap was said to exist. In addition to technical reports, texts and handbooks, an extensive search was made of military publications, especially ISD manuals, Army regulations, training circulars and pamphlets, and military specifications and standards. Also as part of this study TRADOC System Managers (TSM) and their staffs, and other persons tasked by TSMs, were interviewed for the purpose of identifying their information requirements.

Findings:

Adequate techniques do not exist for identifying training and personnel requirements during the early stages of the Life Cycle Management Model. During the Conceptual Phase of the LCSMM in particular, there is a lack of techniques for generating data needed to make estimates of training and personnel requirements. Moreover, there is a lack of techniques for predicting the impact of materiel design on training/personnel subsystems, making it difficult to develop defensible training plans and cost-effectiveness estimates

during the Concept Phase of the LCSMM. More specifically, there is an absence of satisfactory techniques for:

- deducing training and personnel requirements from materiel characteristics, or the reverse
- identifying excessive human resources demands stemming from materiel concepts
- identifying functions most appropriately performed by equipment, persons, or by a man-machine combination
- generating task analytic data during Phase I of the LCSMM
- identifying high-risk training tasks during Phase I of the LCSMM.
- indicating appropriate training strategies before actual hardware is developed
- developing estimates of training costs and training effectiveness for alternative training strategies
- describing human resources data/requirements/constraints in terms that are meaningful to design engineers

It was concluded that solutions to the foregoing technological problems must be developed. If not, it seems unlikely that the gains expected through application of the LCSMM and IPS models will be achieved.

Utilization of Findings:

The results of this technical report will be used primarily as a planning document for further research designed to enhance the early development of the personnel and training subsystems of developing weapons systems. This document will be of interest to all those who are planning research and development efforts that are related to either the IPS or LCSMM models.

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INTEGRATED PERSONNEL AND TRAINING INFORMATION
FOR TRADOC SYSTEM MANAGERS (TSM):
TECHNOLOGICAL GAPS

STUDY OBJECTIVES

This report reviews selected technological gaps and problem areas in existing procedures for the development of training and personnel system development procedures. The report concentrates on deficiencies noted in the application of such procedures during the development, earlier in this study, of a handbook on training management guidelines for use with new materiel systems.

BACKGROUND

During recent years the development of improved procedures for designing personnel and training systems has received considerable attention. Numerous documents containing guidance material for the design and implementation of training and personnel support systems have been prepared. Recognizing the management and coordination problems involved with such efforts, the Army has established TRADOC System Manager (TSM) offices in the U. S. Army Training and Doctrine Command. TSMs "are responsible for the integrated personnel support (IPS) management of selected systems within TRADOC to ensure that personnel and training requirements are developed and fully integrated early and continuously throughout the development cycle" (TRADOC Regulation 600-4). To aid the TSM, handbooks have been developed that describe in general terms the activities and products for which the TSM is responsible (Hanson and Purifoy, 1978; MITRE Corp., 1977).

As part of the present study, a handbook for TSMs (Kinton, 1979) was prepared to provide "a basic reference source of training management guidelines and procedures for use in the life cycle development of Army materiel systems." For each event described in TRADOC Regulation 600-4, Integrated Personnel Support, this handbook outlines the general procedures for accomplishing the event, the sources of event input data, and the use of event products and output data.

During the development of this handbook, certain technological gaps were identified. The major gaps so identified are: the lack of needed data at various points in the formal system development process; the lack of techniques for predicting the impact of materiel design considerations on training/personnel subsystems, and the reverse; and the difficulty of developing defensible training plans and cost estimates during the early stages of materiel development.

The development of solutions to these and other technical problems would greatly enhance the capability of training and personnel system developers.

The design of new materiel systems involves both the design of hardware and the design of an integrated support system, elements of which involve personnel and training (AR 700-127). The orderly and effective development of a new system must include the concurrent development of appropriate training and personnel subsystems. Training and personnel support subsystems may be more expensive than their materiel counterparts. Because of this cost factor and anticipated shortfall of personnel for manning future weapons systems, it is imperative that future systems be designed to minimize the requirements for personnel and the costs for training.

Increased interest in the early design of personnel and training subsystems has heightened our awareness that our ability to identify the relationship between equipment design and personnel and training requirements is both underdeveloped and underutilized. Currently training system development is based on the application of instructional system development (ISD) procedures (TRADOC Pamphlet 350-30). These procedures describe how to generate and process data during a task and skill (front-end) analysis, a type of analysis that depends on the existence of hardware. This conventional task and skill analysis is difficult to perform on an equipment concept, and often is not conducted until a prototype of the new equipment becomes available. By the time such prototypes are available for analysis, it is usually too late for personnel and training considerations to have an impact on equipment design.

Also, within the realm of training, current development procedures do not enable us to make reliable comparisons between alternative training options, especially when the comparisons involve a determination of training and personnel costs over the lifetime of a proposed system.

Historically, the development of new systems involved the design of hardware to meet a set of mission/functional requirements. Often it was tacitly assumed that the human components of the new system could compensate for deficiencies in system hardware or for functional requirements that could not be met by the hardware portion of the system. The approach was to design the materiel in keeping with known physical and physiological limitations of personnel and then to hope that through selection and training a cost-effective man-machine system could be produced.

This approach often resulted in the development of man-machine systems that function less than optimally in the field because

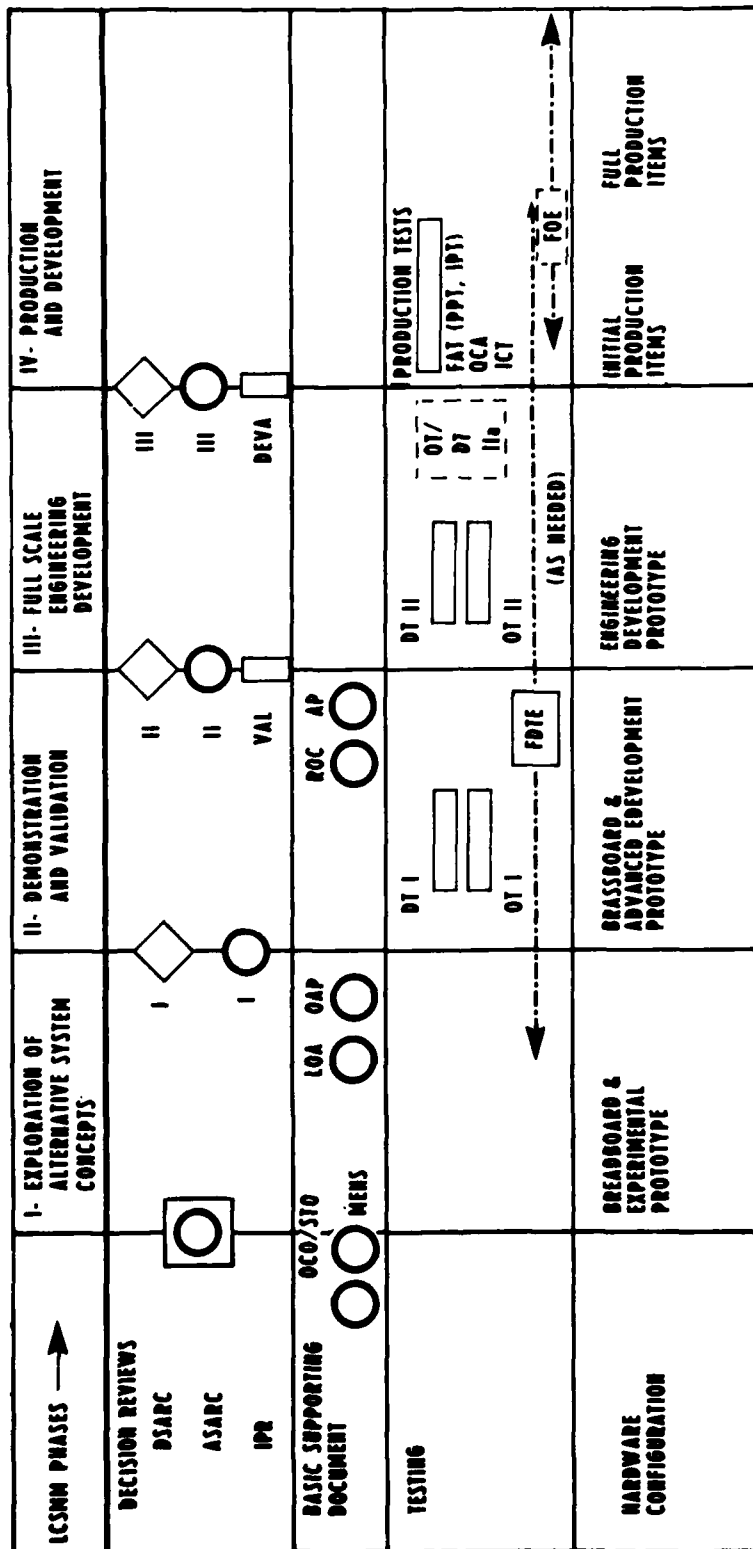
excessive requirements are imposed on operator and/or or maintenance personnel. Such problems tended to be compounded by the belief that the development of a training subsystem could not begin until design of the materiel had been completed. Consequently, it was not unusual for new hardware to be fielded in the absence of suitable numbers and types of persons to man the system.

In recognition of the foregoing problems, the Army developed the Life Cycle System Management Model (LCSMM) for new systems. This model outlines an orderly series of steps that must be accomplished by all sponsor and contractor organizations involved with the development of a new system (DA Pamphlet 11-25). The goal of the LCSMM is to promote the logical, coordinated, and carefully reasoned development of a total system.

As shown in Figure 1 (17), the LCSMM subdivides the total life cycle of materiel systems into four phases--the concept phase, the validation phase, the full-scale engineering development phase, and the production and deployment phase. Numerous regulations, pamphlets, circulars, and handbooks have been prepared to describe the activities that should occur during each of these four phases, including assigned responsibilities and the recommended phasing for various activities. The LCSMM stresses the coordinated development of all logistic support systems in concert with new materiel. Milestones or checkpoints have been established so that independent reviewers can certify that all activities for any particular phase have been accomplished and documented satisfactorily before the system is allowed to progress to the next phase of development.

During Phases I and II of the LCSMM, all portions of the new system progress from a general concept stage through the development and test of prototype materiel and procedures. During this process many design options may be considered, both for materiel and for personnel and training subsystems. To aid in the selection of the most appropriate option, numerous formal and informal trade-off studies may be performed. Some of these studies may examine alternative personnel and training approaches in an effort to identify those that are most cost-effective.

Of particular interest to this report is the identification of the points in Phases I and II of the LCSMM at which human resources data and techniques can have an impact on materiel design. The ultimate goal of the materiel development process is to design a total system providing a cost-effective way to accomplish the mission needs that initiated the development effort. The final system configuration should be a cost-effective mix of materiel, personnel, training, and other elements of the logistics support package.



ASARC - ARMY SYSTEM ACQUISITION REVIEW COUNCIL
 DEVA - DEVELOPMENT ACCEPTANCE
 DSARC - DEFENSE SYSTEM ACQUISITION REVIEW COUNCIL
 AP - ACQUISITION PLAN
 DT I (II) - DEVELOPMENT TEST I (II)
 FOTE - FORCE DEVELOPMENT TESTING AND EXPERIMENTATION
 FOE - FOLLOW-ON EVALUATION
 IPR - IN-PROCESS REVIEW
 LCSNM - LIFE CYCLE SYSTEM MANAGEMENT MODEL
 LOA - LETTER OF AGREEMENT
 MENS - MISSION ELEMENT NEEDS STATEMENT
 OCO - OCCUPATIONAL CAPABILITY OBJECTIVE
 OAP - OUTLINE ACQUISITION PLAN
 OT I (II) - OPERATIONAL TEST I (II)
 ROC - REQUIRED OPERATIONAL CAPABILITY
 STO - SCIENCE AND TECHNOLOGY OBJECTIVES
 VAL - VALIDATION

Figure 1. Systems Acquisition Cycle

METHODOLOGY

This report discusses the needs for improved procedures for developing and making use of human resources data during the design of new materiel systems. These needs, or technological gaps, were identified during the extensive literature review for, and subsequent development of, the handbook for TRADOC system managers (Kinton, 1979) and through interviews with TSMs and their staffs.

For this report a "technological gap" is defined as the absence of documented procedural guidance describing how to accomplish a major event during the development of training or personnel subsystems. This definition allows the inclusion of a wide range of problem areas.

A study of any set of procedures--media selection procedures, for example--will show that they vary considerably in terms of specificity. At one extreme there are general media selection strategies that yield general procedural guidelines which can be implemented by experienced personnel. At the other extreme there should be specific "fully proceduralized media selection job performance aids," which provide detailed, step-by-step instructions and are designed for use by inexperienced personnel. In actuality, such aids do not exist. Military specification MIL-T-29053 (1977) is probably the closest approximation to such a fully proceduralized aid.

Experience gained during this research indicated that guidance material related to training and personnel subsystem development usually falls between the above two extremes. Many textbooks, technical reports, taxonomies, etc. provide the informational content one needs to develop one's own set of detailed procedures. Documents prepared by the military--ISD manuals (Berkowitz and O'Neal, In press), training circulars and pamphlets--military specifications and standards--attempt to provide more detailed procedural guidance. Even in these documents, however, procedures for making key decisions may be omitted, implying that they should be made on the basis of experience plus an understanding of the objectives that must be accomplished.

As an illustration, TRADOC Pamphlet 351-4 contains a detailed discussion of the procedures for selecting tasks for training. However, these procedures are based on the use of either four or eight factors that have to be weighted. They either receive equal weight (by default) or are assigned weights based on a command decision, which in turn usually is based on the professional judgment of experienced combat and training developers.

Technological gaps as defined and discussed in this report will not be eliminated by the preparation of descriptions of strategy and general procedures. They would be eliminated by the preparation of

fully proceduralized performance aids. However, this latter approach would be an extremely lengthy and expensive undertaking.

A more suitable approach to eliminating these technological gaps might be to analyze training development events into their respective tasks, prepare procedural guidance covering these tasks, and prepare training material to cover the accomplishment of elements of those tasks. Essentially, this is the task analytic approach that the Army now follows when developing Skill Performance Aids (SPA).

TECHNOLOGICAL GAPS--MATERIEL DESIGN

DEDUCING TRAINING AND PERSONNEL REQUIREMENTS FROM MATERIEL CHARACTERISTICS

The successful development of major materiel systems is the culmination of a complex series of compromises and trade-offs. The desire for certain equipment capabilities sometimes must be discarded because these capabilities are not feasible within the present state of the art. The desire to meet certain materiel or operational requirements must sometimes give way when it is confronted with the realization that the people needed to man the proposed system cannot be provided. In recognition of these realities, the LCSMM was designed so that materiel-personnel trade-offs can be evaluated at least twice (OT I and II) before the materiel enters into production.

Until recently it was almost inevitable that when materiel and personnel considerations clashed, materiel requirements prevailed. In part this situation stemmed from the common assumption that the development of training programs must await the design of, and be subservient to, materiel developments. Practically all the concepts and procedural guidelines that have been formulated on how to design training subsystems are based on the assumption that training requirements will be deduced from materiel characteristics. Thus, during the development of training and personnel supply subsystems for new materiel, almost all activities are directed toward (a) defining and refining qualitative and quantitative personnel requirements; and (b) designing and refining individual and collective training plans.

During Phase I, the Concept Phase, of the LCSMM, materiel requirements are specified and tentative personnel and training requirements are identified. A major technological gap that exists relative to these activities concerns our lack of knowledge about the relationship between equipment characteristics and personnel requirements. As suggested by Meister (1973),

There is a need for improved guidance for deducing personnel numbers and type requirements from materiel characteristics. In particular there is a need for data relating equipment dimensions to skill dimensions.

During the initial design of materiel, numerous configurations may be considered. Alternatives usually are discarded for other than human resources reasons until one or a few options remain. Within each of these options alternative subsystem designs options may have been identified. For each of these subsystem alternatives, two related questions need to be answered: (a) Given a set of materiel alternatives, do the alternatives have different personnel or training implications, and (b) given any specific alternative, how many persons by MOS and skill level are required to support the system? Data relating equipment dimensions to skill dimensions would be of considerable aid when developing answers to such questions.

Comparability Analysis

A common way of estimating personnel and training requirements for new materiel involves the use of comparability analysis procedures (Goclowski, King, Ronco and Askrew, 1978). The concept of comparability analysis is widely known and practiced. It involves comparing features of proposed materiel with features of similar extant equipment. If comparable subsystems and components are identified, personnel and training data related to those subsystems/components are used to estimate human resources requirements. When comparable subsystems and components cannot be identified, estimates of human resources requirements are based on expert opinion. In practice, personnel and training estimates for new materiel made during the concept phase for that equipment usually are based on a mix of historical data and expert opinion.

The U.S. Air Force has been actively investigating and refining comparability analysis techniques, yet considerable improvements to the techniques are still needed. In particular, Goclowski et al. (1978s, 1978b) report that the techniques do not seem to be extensively employed during the Concept Phase, although this is probably the most profitable locus of application. Therefore, as a technological gap:

There is a need for improved guidance for identifying comparable systems and for historical data to help identify personnel and training requirements, especially during Phase I of the LCSMM.

Identification of Excessive Human Resources Demands

The field of human engineering came about partly because of the need to know how to design materiel that could be operated by persons of specified physical and mental attributes. It is now possible to describe quite accurately how operator stations should be designed, what environmental conditions should not be exceeded, and so on. However, it still is difficult to identify, on the basis of materiel and/or operational concepts, when personnel requirements are excessive. We still design equipment that overloads the operator with data, and we still propose operational concepts that probably will result in excessive physical and mental fatigue before a typical mission is completed. Both Meister (1973) and Goclowski et al. (1978) discuss some of the problems in this area and as a technological gap conclude that:

There is a need for techniques for reviewing materiel and the proposed operational use of materiel in order to identify where excessive demands may be placed on human resources.

Allocations of Functions to Equipment and Personnel

In a text by Meister (1973), excessive personnel demands are discussed in the context of function allocation. During the initial design of a new system, assumptions are made about which functions will be performed by equipment and which by individuals or crews. Engineering handbooks provide general guidance for identifying those types of functions best performed by humans. Meister believes that this guidance needs considerable improvement and as a technological gap reports that:

There is a need for additional research on the conditions under which a function or task should be assigned to operator personnel as opposed to the materiel.

DEDUCING MATERIEL CHARACTERISTICS FROM HUMAN RESOURCES CONSTRAINTS

The discussion so far has been focused on the typical materiel development process--materiel requirements are identified and then personnel and training requirements are deduced. In the past few years it has become obvious that this approach must be modified. Currently and in the future, people requirements may be more difficult to meet than materiel requirements. The traditional design relationship between materiel and personnel requirements may have to be

reversed, placing both the materiel and the training/personnel developers into an unexplored area. In the immediate future the general requirement posed to the materiel developer may be: Given that the materiel will be manned by persons of a specific MOS and skill level, and that personnel quantities and training requirements will not exceed specified limits, design the materiel to meet these constraints.

As noted earlier, better guidance is needed for deducing personnel requirements from materiel characteristics. A more general statement of this requirement, or technological gap, is:

There is a need for more information on the relationship between equipment design and numbers and types of personnel required. This information should provide the basis for deducing materiel requirements from personnel and training requirements/constraints, and vice versa.

Currently, engineers do not know how to design equipment to meet specific skill constraints nor do they know how to design equipment to achieve a reduction in skill level requirements. Moreover, equipment designers cannot answer such questions as: Given a specific number of persons as equipment operators, how should the equipment be configured to provide the most efficient performance?

At one time it was believed that technological advances, especially in automation, would result in materiel that could be operated effectively by less skilled personnel. So far the opposite has proven to be the case. A better understanding of the relationship between equipment dimensions and personnel requirements might have forewarned us of this outcome. Still, it seems helpful to explore ways to make better use of less skilled personnel. Is it possible to trade personnel numbers for skill level so that more persons of a lower skill can operate equipment as well as fewer persons of a higher skill? This and similar questions are worthy of continued study.

INCREASING THE IMPACT OF HUMAN RESOURCES CONSIDERATIONS ON MATERIEL DESIGN

At numerous points during Phases I and II of the LCSMM, materiel design may be affected by human resources considerations and constraints. During Phase I, training and personnel requirements are identified and described in a Letter of Agreement (LOA). While these requirements are being developed, information may be generated to suggest that human resources constraints are being exceeded. During

the allocation of functions to equipment and to personnel (Event A6 of the IPS model, TRADOC Regulation 600-4), a further indication can be derived as to whether proposed operators can or cannot perform the functions assigned to them. From a Cost and Effectiveness Analysis (CEA) of proposed training plans, estimates can be made of the extent to which cost or training time constraints may be exceeded. Finally, during preparation of the Advanced Development Contract, the materiel and training/personnel developers again have an opportunity to judge whether human resources requirements are excessive.

The manner in which human resources data are used by design engineers has received considerable study. Meister (1973) and Kidd and VanCott (1972) note that many crucial design decisions are made during preparation of the AD contract proposal and are never controverted. A proposal preparation team for a large system will include human factors engineers, especially if the contract states that HFE will be considered when developing the design for the proposed system. However, the mere presence of HF personnel is not enough. These persons must be willing to offer specific suggestions in response to specific questions about personnel and training (1972). Also, they must be willing to perform a rough task and skill analysis (TASA) quickly and on the basis of materiel concepts. This analysis should concentrate on (a) identifying excessive operator requirements; (b) calculating results/impact of excessive requirements; and (c) identifying equipment characteristics that might minimize personnel and training problems (10). The techniques for accomplishing the TASA in the absence of equipment have not been developed. Thus:

There is a need for procedures describing how to quickly perform task and skill analysis as part of the process of refining design concepts, and then translating the data into estimates of training and personnel requirements.

Askren (1973) and Chapanis (1976) have noted that the way personnel and training requirements/constraints are typically worded has little meaning for a design engineer. The statement that the equipment must be designed to be operated by persons holding MOS XXX at the 3 skill level has no meaning to an engineer. His only recourse is to inquire whether similar extant equipment can be operated by such personnel. If so, that is the end of his consideration of personnel requirements.

As another illustration, the requirement that the total training program for the new system not exceed a cost of \$5 million per year, adjusted for inflation, has no design implication for equipment designers. These illustrations indicate that:

There is a need for guidelines on how personnel and training recommendations/constraints should be worded so that design engineers can understand them and use them.

There is a need for ways to display human resources data so that their impact on materiel design or on training and personnel requirements becomes more obvious.

The need for improved ways to display human resources data will be discussed later in this report.

TECHNOLOGICAL GAPS--TRAINING PROGRAM DESIGN

The state of the art for training technology has shown substantial advances in the past two decades. Instructional system design procedures were developed, and refinements continue to be made. Task and skill analysis techniques have been considerably refined, especially as applied to the preparation of SPA materiel. Practically all these advances, however, are based on the generation of data from existing systems. As already noted in this report, techniques for applying training technology during the Concept Phase of new materiel development have not been well developed. Some of the technological gaps in this area will now be reviewed.

TASK AND SKILL ANALYSIS FOR DEVELOPING SYSTEMS

TRADOC Regulation 351-4 emphasizes the importance of selecting tasks for training during the early stage of the training development process. This regulation also stresses the importance of developing a complete inventory of tasks prior to task selection.

Some of the problems associated with developing a task inventory for new materiel already have been discussed. The techniques for developing the inventory depend in part on comparability analysis techniques, and these techniques need further refinement. Also, the inventory depends in considerable measure on how functions are allocated between operator positions and the equipment. Function allocation is another area in which adequate techniques do not exist.

Chapanis (1976) has discussed the difficulty of anticipating the need for training to handle emergencies. He notes that with highly automatic systems, operators monitor system operation until something happens. Then they must respond rapidly and accurately. For systems in the development stage, it is difficult to anticipate emergency

situations; it is easy to overlook tasks that must be performed to correct operational emergencies or hazardous situations. The difficulty of identifying situations in which excessive operator requirements may result from materiel design or operational concepts has already been noted.

Improved procedures for anticipating these situations should be developed. In all probability, emergency situations would be identified as mission-critical or high-risk tasks for which appropriate training material should be developed. In extreme instances, personnel studies during the Concept Phase might demonstrate that the proposed design of the hardware must be modified because personnel training and/or selection procedures cannot be expected to provide persons able to cope with one or more of the emergency situations.

The training development procedures that can be utilized in the above problem areas are, for the most part, applicable primarily to individual tasks. Analysis techniques for developing an inventory of collective tasks (tasks performed by crews or units) are seldom described in the literature. The most recent guidance for task and skill analysis (TRADOC Pamphlet 351-4 and MIL-M-63035) does not address the analysis of collective tasks. In view of these considerations it appears that:

There is a need for better techniques for applying task and skill analysis procedures, especially those related to the development of task inventories, during the Concept Phase of the LCSMM. In addition, there is a need for improved guidance for developing an inventory of collective (crew) tasks during all stages of the LCSMM.

Selection of Tasks for Training

A training system does not attempt to provide training for all individual and collective tasks. Many tasks are simple enough, or common enough, that training is not required. There are tasks that can be described well enough in technical manuals or in job performance aids so that training is not required. Also, there are tasks that must be taught by informal on-the-job training because funds are not available to cover them during institutional training or in extension training material. Finally, there are some tasks that are not trainable.

The selection of tasks for training is an extremely important activity. For developing systems, training task selection is a designated milestone. It is an activity performed jointly by the materiel and training developers, and the result is an agreed-upon list of tasks that will be covered by a training program or by SPA material.

ISD manuals--TRADOC Pamphlet 350-30, and especially TRADOC Pamphlet 351-4 devote considerable attention to the task selection process. The most time-consuming and difficult task selection model considers eight factors: percent of persons performing task, percent of time spent performing task, consequences of inadequate performance, task delay tolerance, frequency of performance, task learning difficulty, probability of deficient performance, and immediacy of performance or time between job entry and task performance. A simpler version of this model, bases task selection on only four factors: percent of persons performing task, task delay tolerance, consequences of inadequate performance, and task learning difficulty. These are the four factors that many practitioners judge to be of greatest importance. Both of these models employ data that may be difficult to generate for developing systems, especially during the Concept Phase when the model must first be applied.

A third model, the DIF Model, selects tasks on the basis of supervisor, job incumbent, and/or subject matter experts' judgments about difficulty (D), importance (I), and frequency (F).

More research is required on the ease of use and the validity of each of these models. In particular, further guidance is needed on how the factors in each of these models should be weighted. Currently weighting seems to be based on a command position that is developed on the basis of professional judgment.

To further emphasize the importance of task selection during Phase I of the LCSMM, it should be noted that data based on this activity are used to prepare an Outline Individual and Collective Training Plan (OICTP), which in turn is used to prepare a Training Support Plan. The result is a refined OICTP that provides the data for a Cost Effective Analysis of the proposed training plans--the analysis that provides the basis for judging whether the training plans are acceptable. If they are accepted, the OICTP identifies those tasks for which training material/programs will be prepared prior to OT I. Thus, the selection of tasks for training during Phase I merits increased emphasis. In view of these considerations it seems appropriate to conclude that:

There is a need for further investigation of the models that may be used to select tasks for training.

DEVELOPMENT OF TRAINING STRATEGIES

During the Concept Phase of the materiel development process, estimates are made of the personnel, by MOS and skill level, required to operate and maintain the new system. The tasks selected for training are then allocated among these proposed operator and main-

tenance positions, and a training plan outline is prepared for each duty position. These training plans contain little detail. Rather, they depict the training strategy by which personnel resources will be developed. These strategies contain estimates of training settings, training media, need for training devices, need for SPA material, and so on.

Considerable guidance exists as to how to make such estimates once detailed task and skill analysis data are available. However, such guidance documents seldom discuss the application of these techniques during the Concept Phase. For example, TRADOC Pamphlet 350-30 and TRADOC Pamphlet 351-4 both review procedures for selecting instructional settings, but the readers of these documents are on their own when applying these procedures to new materiel. Similarly, numerous procedures exist for selecting media but these procedures do not address media selection during the Concept Phase of materiel development. In fact, a recent report (Honeywell, 1978) suggests that media selection techniques in general need considerable improvement.

Recent and on-going studies have been concerned with improving guidance on designing training devices. When training devices are first considered in the Concept Phase, the question is not how to design them but rather whether they are needed at all. The problem is one of deciding the strategy for using training aids and devices. This involves making tentative selections among actual equipment trainers, simulators, mock-ups, training aids, and so on. Further, it involves estimating training device requirements in terms of the stage of learning that the device is to support. The relationship between stages of learning and training devices requirements has not been fully explored. However, an article by Miller (1974) summarizes many of the practical findings in this area.

According to Meister (1973) there is need for a task taxonomy that would say: Given this task, equipment should be designed this way and training should proceed as follows. The considerable research that has gone into development of task taxonomy, plus their conspicuous non-use, makes one wonder whether a useful taxonomy relating tasks to training strategies can be developed.

A favorable indication comes from the observation that experienced training developers can look at many operator and maintenance tasks and readily describe one or two strategies for teaching that task. The major tasks performed by maintenance personnel already have been classified into a small number of categories--inspect, troubleshoot, adjust, remove/replace, etc. The development of two or three different strategies for teaching each of these groups of tasks should assist the preparation of an OICTP during the Concept Phase. Similar groupings could be developed for operator tasks followed by

the development of training strategies for each. With respect to a technological gap that seems capable of being successfully treated:

There is a need for procedures, based on a task taxonomy approach, that would allow one to identify acceptable alternative training strategies for common operator and maintenance tasks. These procedures should address the additional factors that should be used to select from among the alternatives.

TECHNOLOGICAL GAPS--COST AND TRAINING EFFECTIVENESS ANALYSIS

More research is needed to provide guidance on applying cost-effectiveness techniques to the process of selecting training subsystems. TRADOC Pamphlet 71-10, no longer in force, provides a good description of various types of Cost and Training Effectiveness Analyses (CTEA) and some guidance on the general methodological approaches required by each type. Two on-going ARI-sponsored studies^{1,2} each will prepare a guidance document describing how to conduct a CTEA. Also, a new regulation covering CTEAs is being prepared by the Army's TRADOC System Analysis Agency (TRASANA).

At present there is a tendency, created by the lack of specific guidance, to satisfy the CTEA requirement by showing that the use of simulators is less costly than the use of actual equipment for training operator and/or maintenance personnel. Although this procedure is often necessary, it may not be adequate. Other alternatives to the simulators may not have been evaluated and thus a "least cost" training solution was not reached. This tendency toward the cost-effective evaluation of training devices rather than of the entire training subsystem is caused by:

- (1) A lack of basic data needed to perform such evaluations.
- (2) A lack of comprehensive methodologies to apply to the various types of CTEAs.
- (3) A lack of guidance for determining which type of CTEA and which methodology to use at a particular point in the LCSMM.

¹Development of a Cost/Training Effectiveness Manual for Use in LCSMM, ARI, Fort Bliss.

²Effectiveness of Infantry Systems: TEA, CTEA, and Human Factors in System Development and Fielding.

Admittedly this is a sequential type of problem; methodologies are not developed because basic data are not available, and guidance is not necessary because the methodologies are not developed. The problem is certainly not being ignored. Several on-going research efforts at ARI are exploring various aspects, and TRASANA is preparing to provide technical assistance in the performance of CTEAs for systems in the future. These efforts will undoubtedly improve the CTEA process. What is necessary is a comprehensive plan for incorporating the improvements achieved into the LCSMM.

The greatest shortfall in this area is the lack of basic data in the early (conceptual) phase of system development. The training subsystem, and possibly several alternatives, must be postulated from a list of critical tasks provided by the materiel developers. There are methods for accomplishing this process, some described in the accompanying handbook (11), but no significant basic data. The entire process is essentially a judgment call. It should be possible to compile our previous knowledge of system development and associated training subsystem development in such a way as to make the process of postulating a new training subsystem more deductive. As an example a handbook could be prepared in the fashion of weapons effectiveness handbooks, providing the basic relationships needed to determine training strategies in a simple and refinable format.

Cost data for CTEAs are more readily available but often are located in the files of specific users rather than being disseminated for general use. A compendium of the latest cost information and computations techniques, providing the cost of additional weeks of training, identifying the cost elements and sources of latest information on each, displaying unit training costs, etc., would be of great value to the CTEA study proponent.

If the above basic data were available, the necessary methodologies would evolve. In fact, some have. Approaches, some automated, have been developed for such areas as cost-effective selection of training media. Their use, however, is predicated on the availability of basic data, such as which media approach provides higher student performance on each of the critical tasks. Such decisions, particularly in the Concept Phase, are at present subjective, thus degrading the results of the media selection methodology. Methodology development should continue, but its need for basic data--which do not exist--should be considered, and the necessary basic research performed to provide the data.

The guidance problem also requires some research. TRADOC Pamphlet 71-10 describes three types of CTEAs--Train-up Study, (TUS), Training Analysis Cost and Operational Effective Analysis (TAC), and Training Developments Study (TDS). Although this document is no

longer in force, the descriptions of CTEA types and the requirements of each type remain pertinent. Each may be a screening CTEA (quick-look) that determines whether further analysis is necessary. If it is, the TUS and the TDS are performed as stand-alone efforts and the TAC is provided as input for the COEA. The problem is in determining where in the LCSMM each type of study should be performed, if needed, and what methodology to use with the data available at the time.

TECHNOLOGICAL GAPS--CODIFICATION OF HUMAN RESOURCES DATA

Training and human factors personnel are quick to criticize engineers for not employing human resources data during the design of materiel. As already noted, however, there is a lack of data describing how equipment should be designed to accommodate various types of persons or to foster proficient performance on various types of tasks. Moreover, as Meister has observed (1973), very few techniques are available for describing human resources data in terms that are meaningful to the design engineer.

Experience with system development and with trade-off studies over the years has identified the need for human resources data to show the relationship of personnel/design/training/costs, generalized from system experience and research, in the same way that human engineering data have been displayed. There is a need for handbooks containing charts, graphs, tables, etc. which show the relationship between hardware characteristics and training time, personnel characteristics and training, numbers of personnel vs. costs, and so on. Such handbooks of data packages could be used by training developers as they develop data for cost trade-off studies.

Persons in the human resources community are inherently reluctant to make general estimates of the relationships between factors unless these relationships have been confirmed under controlled conditions. However, time and time again these same persons are asked to make estimates about the quantities and types of persons needed to perform certain tasks, or about the most effective form(s) of training programs for teaching various tasks or various types of students.

Anecdotal evidence suggests that experienced personnel can make fairly accurate estimates of human resources requirements for various types of proposed materiel, especially if the proposed materiel is an advanced version of something that exists already. Studies for the Air Force's Human Resources Laboratory (Whalen and Askren, 1974) have shown that technicians can make accurate predictions about the parameters of general types of human resources data during the conceptual design phase. As an illustration, experienced personnel can quite

accurately estimate the average time required to repair various equipment subsystems and the size and composition of flight line repair crews.

Without attempting to base the relationship of functions on actual data, the data form of the relationship for various functions which enter into materiel-personnel/training trade-off studies may be depicted as shown in Figures 2 and 3.

Figure 2 illustrates the probable relationship between training time and aptitude scores. Training time might be shown in hours, weeks, or months and aptitude scores expressed in terms of clerical, electronic or mechanical aptitude with different charts prepared for different aptitudes. Such charts should be useful for determining the cost-effectiveness of certain approaches. For example, one could compare an approach that used large numbers of less capable persons with an approach that used fewer persons of a higher capability.

Figure 3 illustrates the probable relationship between maintenance man-hour requirements and the number of replaceable parts in the system. Parameters X, Y and Z represent average materiel reliability specifications. From such a chart, one could determine that the number of maintenance personnel required for a system is related to the number of parts that can fail (replaceable parts) and the reliability criterion for each part.

Many operator and maintenance tasks are quite similar across materiel systems. For each of these tasks two or more equally acceptable training strategies usually can be developed. However, these strategies may differ widely in terms of support requirements. It would seem possible, for such common tasks, to outline a set of training strategies for each and describe the implication of each strategy in terms of factors such as materiel training device, and instructor requirements. This information then could be used during trade-off studies and during Cost and Training Effectiveness Analysis studies.

In view of the foregoing considerations the authors believe that:

Charts, graphs, tables, and other forms of handbook material should be prepared to summarize professional judgments about the relationships among: (a) equipment characteristics and personnel/training requirements; (b) task requirements and materiel and/or operational requirements; (c) task requirements and work demand conditions; and (d) task requirements and probable time and/or cost to train.

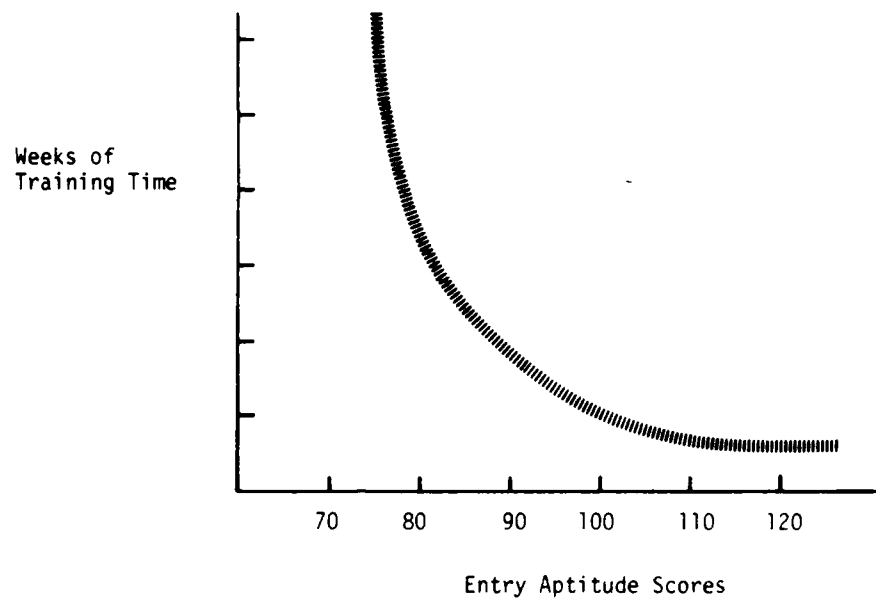
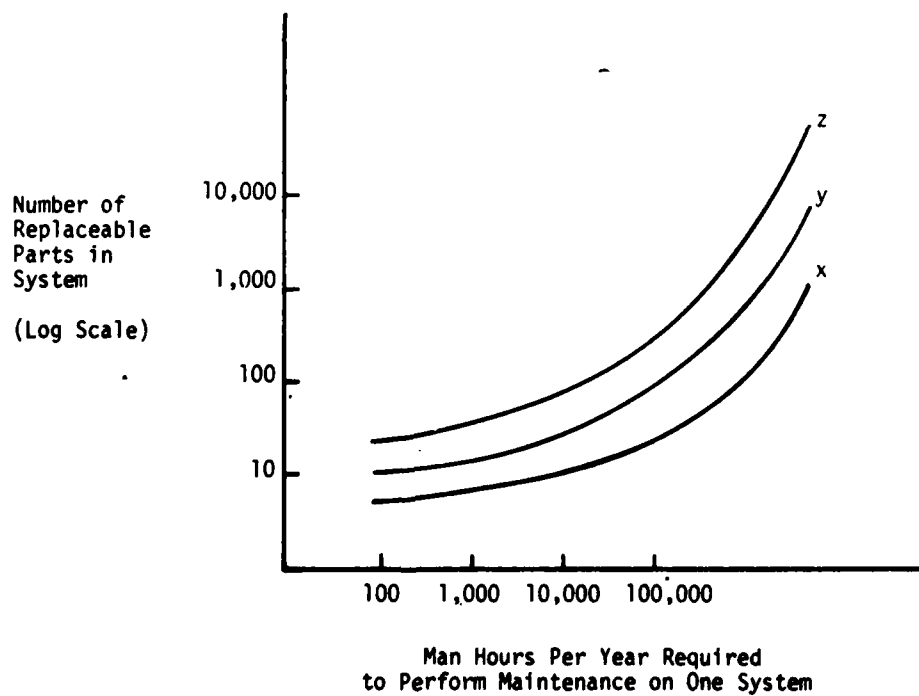


Figure 2. Training Time vs. Aptitude Scores



Where parameters x, y, and z represent average (hardware) reliabilities of 90, 95 and 99%

Figure 3. Man Hours Required vs. Number of Parts

SOME CONCERNS OF TRADOC SYSTEM MANAGERS (TSMs)

As part of this project TRADOC System Managers (TSMs) and their staffs, and other support personnel were interviewed for the purpose of identifying their information requirements. TSMs located at Forts Bliss and Sill were contacted, as were persons associated with the Training Development and Course Development Directorates at these two schools. Personnel attached to the Army Research Institute's Field Units at these posts also were queried. All were questioned regarding their activities relative to preparation of training programs for developing systems, the sources of information they use when engaged in such activities, their use of existing TSM handbooks, and their need for additional information concerning the developing of training subsystems for new materiel.

Based on these interviews, 26 problem areas were identified. These areas are listed in Table 1 and described in more detail in Appendix A. The interviewees also identified certain topics and content that might be included in future handbooks for TSMs. These are listed in Table 2 and described more fully in Appendix B. The interviewer's findings are summarized in the following paragraphs.

Currently most new systems are being developed on an accelerated schedule, and there is a concerted effort to reduce the entire developmental cycle to about five years. This is being attempted through the elimination of DT/OT III, and the complete or at least partial elimination of DT/OT I. Further, most of the studies, documents, training materials, and training equipment which should be developed prior to DT/OT II are being prepared by the prime contractor(s). As a consequence, it appears that many of the training and human factors considerations which should be addressed during Phases I and II of the LCSMM are receiving, or will receive, minimum attention. It seems probable, therefore, that many of the training system development problems which the Integrated Personnel Support procedures were designed to alleviate will instead be exacerbated by efforts to reduce and/or bypass major portions of the training system development process.

The interviewers were impressed with how much of the integrated personnel support system for new systems is contractor developed. This is now the rule, rather than the exception. Neither TSM offices nor School Directorates have the personnel needed to prepare the various documents and conduct the various studies called for in TRADOC Regulation 600-4. In the typical case, Individual and Collective Training Plans, Training Device Requirement studies, provisional QQPRIs, training materials, and training devices are developed under contract. Currently, the critical task of TSMs and other Army personnel is to monitor and evaluate contractor activities and products, and guidance for doing this needs considerable improvement.

Numerous TSMs expressed the need for "backward planning" guidance. They desire a document that will help them plan backwards from a scheduled ASARC/DSARC review or an Operational Test date. This guide should describe the documents and materials which must be prepared prior to those scheduled activities, approximately how long it will take to prepare the documents/materials, and who is responsible for preparing them.

At both Fort Bliss and Fort Sill, TSMs are located in adjoining offices, yet there appeared to be little formal effort to exchange experiences. In explanation of this seeming lack of cooperation, the interviewers were told that each new system is different, is at a different stage in the LCSMM, and is following a somewhat different time line. Because of these considerations, many TSMs were of the opinion that a detailed handbook for TSMs would have little overall value. Some noted, however, that efforts to identify exemplary documents and disseminate these as models to all TSMs would be useful. They also noted that the main commonality between all systems is the requirement to hold scheduled ASARC/DSARC reviews at the end of each phase of the LCSMM.

There was disagreement regarding the usefulness of handbooks for TSMs. All TSMs were aware of the MITRE and ARI/TRADOC (Hanson and Purifoy, 1978) TSM handbooks but reported little use of them. Some interviewees discussed the need for more detailed "how to do it" manuals for TSMs, manuals that would consolidate other references and serve as a prime source document. Other interviewees were of the opinion that detailed handbooks get out of date too quickly and do not provide for enough flexibility of action; they favored the preparation of guidebooks rather than "cookbooks".

Table 1

PROBLEMS IDENTIFIED BY TRADOC SYSTEM MANAGERS
AND ASSOCIATED PERSONNEL

1. Compression of LCSMM into five years does not allow for enough time to concurrently develop a training system.
2. Human factors problems receive little consideration until an advanced prototype is available at OT II.
3. Most training-related documents, studies, and material for new systems are developed under contract. This increases the monitoring/evaluating burden of Army personnel.
4. Documents describing the LCSMM process are of only general use because each system is being developed under a different schedule.
5. Front-End Analysis (FEA) data often are acquired on an untimely and incomplete basis.
6. More guidance is needed regarding how to state training system requirements in RFPs and in contracts.
7. Better guidance is needed regarding how to evaluate statements of training device requirements (TDRs) as well as any training devices developed under contract.
8. Better guidance is needed regarding how to monitor and evaluate contractor efforts.
9. Improved guidance and methods are needed to support the conduct of CTEAs and COEAs.
10. Better guidance is needed regarding the staffing of the various documents which must be produced during the LCSMM.
11. TSM authority to task other TRADOC agencies is not clear.
12. More information about budgeting cycles and related lead times is needed by most TSMs.
13. Improved guidance is needed regarding how to prepare for ASARC/DSARC reviews.

Table 1 (Continued)

14. Better guidance is needed regarding how to "backward plan" from LCSMM milestones.
 15. Improved guidance is needed regarding the format and contents of LCSMM-related documents.
 16. No mechanism exists for identifying exemplary documents and informing TSMs about such documents.
 17. No formal procedures exist for sharing information among TSMs.
 18. More guidance is needed regarding how to manage the development of systems under the Rationalization, Supportability, Interoperability (RSI) Program.
 19. Some LCSMM-related documents that are not now action documents should be so designated.
 20. Inaccuracies in Reliability, Availability, Maintainability (RAM) data can lead to conflicts regarding QQPRIs.
 21. Better and less cumbersome media selection techniques are needed.
 22. Validation of SPA material sometimes does not occur until after OT II.
 23. Logistics agencies are sometimes slow to provide inputs to TSMs.
 24. The definition of Initial Operational Capability (IOC) is unclear.
 25. Persons assigned to a TSM's staff should be familiar with the general developmental cycle for new equipment.
 26. No satisfactory procedures exist for preserving the "institutional experience" developed within a TSM office.
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Table 2

SUGGESTED TOPICS/CONTENT FOR TSM HANDBOOK

1. Backward planning guidance
 2. Proponent planning guidance
 3. Information about the format and content requirements of key documents
 4. Guidance regarding the preparation/review of RFPs and contracts
 5. Guidance regarding how to monitor contractor efforts and to evaluate contract deliverables
 6. Information describing TSM involvement with Operational Testing
 7. Guidance regarding the role of other TRADOC agencies
 8. Guidance regarding the conduct of CTEAs
 9. Guidance regarding the Rationalization, Supportability, Interoperability (RSI) program
 10. Guidance regarding how to assure consideration of human factors during early phases of the LCSMM
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SUMMARY AND CONCLUSIONS

The Life Cycle System Management Model (LCSMM) outlines an orderly sequence of steps that must be accomplished during the development of new materiel systems for the Army. The Integrated Personnel System (IPS) model describes a related series of steps that should be followed to ensure that cost-effective and timely training and personnel subsystems are developed and tested concurrent with materiel development. It is anticipated that systems developed under these two models will be developed more rapidly, will be more cost effective, will have more effective support subsystems, and will require less retrofitting once they become operational.

The findings of this report suggest that the gains expected through application of the foregoing models will not be achieved because the techniques for executing various steps in the models exist only in rudimentary form, if at all. This conclusion is based on the existence of three categories of technological gaps which prevent adequate development of personnel and training subsystems until an advanced prototype of system hardware has been produced. These gaps concern:

- (1) The lack of techniques for generating needed data at various points in the LCSMM development process.
- (2) The lack of techniques for predicting the impact of materiel design on training/personnel subsystems, and conversely, the impact of these subsystems on materiel design.
- (3) The difficulty of developing defensible training plans and cost-effectiveness estimates during the early stages of materiel development.

The existence of these and related technological gaps has been recognized for some time, and efforts are underway to fill these gaps with improved techniques. These efforts must continue, if the objective of fielding new materiel systems with well-trained personnel is to be achieved.

During Phase I of the LCSMM, alternative materiel concepts are investigated, and for each concept personnel and training requirements must be estimated. Development of these estimates is hindered by the absence of satisfactory techniques for:

- (1) Deducing training and personnel requirements from materiel characteristics.
- (2) Identifying excessive human resources demands stemming from materiel concepts.

- (3) Identifying functions most appropriately performed by equipment, by persons, and by some man-machine combinations.

During this Concept Phase of the LCSMM, the cost effectiveness of alternative training plans must be assessed. This process depends on the development of task and skill data, the identification of high-risk training tasks, and the development of training strategies. Existing Instruction System Development techniques and task analytic techniques for accomplishing such activities assume that hardware exists. However, during the Concept Phase for developing systems prototype hardware does not exist. Thus, important personnel and training decisions now must be based on guesswork or on data from comparable systems or both. There is a need, therefore, to devise techniques that can be applied during the Concept Phase of developing systems to generate task analytic data, identifying high-risk training tasks, and indicate appropriate training strategies before the actual hardware system is in existence.

For future materiel systems it is quite possible that training and personnel support subsystems will be more costly than their materiel counterpart. Therefore, better techniques are needed for developing estimates of training costs and training effectiveness for alternative training strategies. Currently, baseline data upon which to conduct cost studies of training and operational effectiveness are usually lacking during the LCSMM Concept Phase. Also, there is an absence of comprehensive and standardized methodologies for accomplishing such studies. On-going ARI-sponsored research may correct this technological gap.

Human factors and training personnel often complain about the lack of attention given to human resources considerations during materiel design. Air Force studies have documented the legitimacy of such complaints. However, many authors have noted the almost total absence of techniques for deducing materiel characteristics from human resources constraints. Techniques do not exist for describing human resources data and/or requirements in terms that are meaningful to design engineers. Until this technological gap is filled, it is unlikely that materiel will be designed to meet anticipated constraints in human resources.

In the past, new systems were designed to meet certain mission or functional requirements, and it was assumed that, through selection and training, the human components of the new system could compensate for deficiencies in system hardware or for functional requirements that could not be met by the hardware portion of the system. This assumption is no longer tenable. The high cost of future training and personnel systems, plus the anticipated shortfall of persons having appropriate capabilities, makes it imperative that future systems be

designed to minimize training and personnel costs, while at the same time minimizing the need for exceptional personnel.

APPENDIX A

Problem Areas Identified by TRADOC System Managers (TSMs) and Other Training Proponent Personnel

1. Compression of LCSMM into five years does not allow for enough time to concurrently develop a training system.

Most new systems are being developed under an accelerated schedule. OT III is being eliminated, and in some instances OT I is being slighted or bypassed. When OT I is bypassed, competing contractors develop prototype equipment which is first evaluated during a test similar to OT II. The results of this evaluation, along with contractor-developed proposals for training systems, are used to select the winning system. Limited production then will begin. The foregoing developmental schedule probably will result in the deemphasis of training and human factors considerations during the first two phases of the LCSMM. It seems probable also that, because of competitive reasons, contractors will be reluctant to allow Army personnel to monitor their contractual efforts prior to the initial evaluation of the competing systems.

2. Human factors problems receive little consideration until an advanced prototype is available at OT II.

Potential human factors problems should receive initial consideration during Phase I of the LCSMM, and should receive extensive consideration during Phase II. In practice, human factors problems receive little consideration until after OT II. For example, OT I or its equivalent may be based on an evaluation of the feasibility of available technology or on an evaluation of unintegrated portions of the proposed system. It is difficult to identify potential human factors problems during such types of evaluation. Thus, human factors problems may not be identified until OT II. By this time it is difficult to effect major changes in the hardware. This is likely to happen for those systems being developed under the Rationalization, Supportability, Interoperability (RSI) program. Under this program all equipment changes must be coordinated with and agreed to by allied representatives. For some equipment provision has been made for early inputs to Human Engineering Laboratory (HEL). However, these inputs often are made after OT I.

3. Most training-related documents, studies, and material for new systems are developed under contract. This increases the monitoring/evaluating burden of Army personnel.

The current trend is to contract out the development of as much of the training system as possible. This means that Army employees will be used increasingly to monitor and to evaluate the development of training materials. Guidance regarding how to accomplish this needs considerable improvement. Currently one can refer to various Military Standards to determine whether SPA materials meet various requirements. However, there are no standards for evaluating training devices or such documents as Individual and Collective Training Plans (ICTPs), provisional QQPRI, and so on.

4. Documents describing the LCSMM process are of only general use because each system is being developed under a different schedule.

The development schedule for a new system depends on how different it is from current systems, recent re-evaluation of the threat which the system is designed to meet, recent technological advances, and so on. Furthermore, many systems now under development were begun before current LCSMM procedures were established. Thus, the time schedule for each system is different (and determined primarily by the Project Manager); certain key documents required by the LCSMM are prepared on a retroactive basis; and certain key steps in the LCSMM are bypassed on a "management by exception" basis. For these and other reasons TSMS do not pay much attention to the details of the LCSMM. What they attend to are scheduled ASARC/DSARC reviews. The schedule for these reviews plus the scheduled time of IOC is what drives the entire developmental cycle.

5. Front-End Analysis (FEA) data often are acquired on an untimely and incomplete basis.

Front-End Analysis data supposedly are supplied initially following award of the Advanced Development contract and are updated after each Operational Test. These data are provided by the contractor. Typically, they are not provided until after OT I and sometimes not until after OT II. The Army finds that FEA data provided for the purpose of developing a Preliminary ICTP, QQPRI, Test Plan for OT I, etc., usually are late in arriving and often are incomplete. This may be a contractual problem which can be alleviated by more specific contractual guidance and requirements. If this practice is to continue, the Army must be allowed to monitor the development of these plans and documents in order to synchronize other subsystem development.

6. More guidance is needed regarding how to state training system requirements in RFPs and in contracts.

TSMs and persons associated with school directorates often are involved in the preparation of, or at least the review of, RFPs and contracts. The preparation of these documents for new systems is of critical importance because contractors are asked to produce many of the products which heretofore were developed by Army employees. It is especially important that the contract be written so that military personnel will have the opportunity to closely monitor the development of documents and material related to the training system. MIL-STD-1388 (14) describes how SPA requirements should be written into an RFP. Interviewees expressed a need for better guidance in other areas.

7. Better guidance is needed regarding how to evaluate statements of training device requirements (TDRs) as well as any training devices developed under contract.

According to the LCSMM, training device requirements should be identified in conjunction with the development of a preliminary Individual and Collective Training Plan. The guidance implies that TDRs should be developed by Army personnel. In practice the requirement to identify TDRs often is incorporated into an RFP or a Required Operational Capability (ROC) document. In such cases the contractor has the responsibility for both identifying the need for training devices and developing such devices. The responsibility of Army personnel is to evaluate any statement of TDRs and any devices developed by the contractor. Better guidance is needed on how to accomplish this.

8. Better guidance is needed regarding how to monitor and evaluate contractor efforts.

As noted already, most of the documents and deliverables associated with the LCSMM are produced under contract. The Army is responsible for monitoring the development of these products and for their evaluation. Numerous interviewees reported that there is little guidance in these areas, and that the development of improved guidance would be useful.

9. Improved guidance and methods are needed to support the conduct of CTEAs and COEAs.

The interviewees reported that little guidance exists regarding how to conduct a Cost and Training Effectiveness Analysis (CTEA). In addition to general guidance, the interviewees desired more information on detailed methods for accomplishing CTEAs. This need already has been recognized and is the subject of on-going, ARI-sponsored research.

10. Better guidance is needed regarding the staffing of the various documents which must be produced during the LCSMM.

TSM personnel did not agree as to the need for more detailed guidance regarding the staffing of various documents and studies. However, some TSMs and/or their staffs, reported that for certain documents the staffing guidance was not clear.

11. TSM authority to task other TRADOC agencies is not clear.

To accomplish their mission TSMs are authorized to interact directly with other Army agencies. In most instances the nature of this interaction is spelled out rather well in regulations. However, TSMs also are authorized to use the services of other TRADOC agencies. The nature of this authority apparently is not as clear as it might be. Some TSMs expressed a desire to know more about their authority to task other TRADOC agencies, what these other agencies could do for them, the procedures for gaining their assistance, and the appropriate entry points to these agencies.

12. More information about budgeting cycles and related lead times is needed by most TSMs.

TSMs continually discover that they cannot obtain large amounts of school support until the support requirements have been placed in the school budget. This takes time. For example, if instructors are required for OT II, it may take up to 29 months to obtain these instructors through the normal budget cycle. If new facilities are required for training, it usually takes five years to obtain these facilities. TSMs and their staffs seldom are aware of the specific lead-time requirements associated with their various requests. This type of information would be of use to them. The Field Artillery School has developed a budgeting slide rule which provides this information, and has made it available to TSMs. Similar devices have been developed for use at other Army schools.

13. Improved guidance is needed regarding how to prepare for ASARC/DSARC reviews.

There are four key dates in the LCSMM: the Initial Operational Capability (IOC) date, and the three ASARC/DSARC review dates. During each ASARC/DSARC review, a particular set of issues is addressed and a particular set of documents and other deliverables should be available. Numerous TSMs expressed an interest in having more definitive guidance regarding how to prepare for ASARC/DSARC reviews. In particular they wanted better guidance regarding the documents and deliverables that should be ready prior to these reviews. This is in keeping with the expressed needs of TSMs for more information that can be used for backward planning.

14. Better guidance is needed regarding how to "backward plan" from LCSMM milestones.

As previously mentioned, the critical dates in the LCSMM are those associated with the ASARC/DSARC reviews and with the IOC. Numerous TSMs expressed an interest in being provided with more backward planning guidance, especially with reference to ASARC/DSARC reviews. They would like to know what documents and other deliverables need to be ready at these points; they would like to have estimates of the time required to develop these deliverables; and they would like to know who should be tasked to develop the deliverables. The Directorate of Course Development at the Field Artillery School has developed a slide rule that can be used to determine lead time requirements for accomplishment of various training-related actions. More planning guidance of a similar nature would seem appropriate.

15. Improved guidance is needed regarding the format and contents of LCSMM-related documents.

In most cases each major document required as part of the LCSMM is described in a regulation. However, these regulations do not describe in detail the format of some of the required documents nor the topics that should be addressed. Numerous persons felt that more guidance, with examples, would be useful.

16. No mechanism exists for identifying exemplary documents and informing TSMs about such documents.

No formal means have been established for identifying good examples of LCSMM-related documents and disseminating this information to all TSMs. The TACFIRE ICTP has been labeled as a "GOOD" example of an ICTP and has been distributed to most TSMs. It was suggested that the TRADOC TSM Office might try to identify other exemplary documents and provide these to all TSMs.

17. No formal procedures exist for sharing information among TSMs.

As noted previously, there are no formal mechanisms for sharing information among TSMs. Most TSMs were of the opinion that some sort of information sharing should be useful, and suggested that the TRADOC TSM office might assume responsibility for such actions.

18. More guidance is needed regarding how to manage the development of systems under the Rationalization, Supportability, Interoperability (RSI) program.

Some of our new systems are being developed in cooperation with our allies. This means that prototype equipment and draft training material must be approved by a committee composed of all concerned parties, and changes cannot be made unless approved by all parties. Apparently, there is little guidance regarding what type of changes will have a major impact on the system and will require an agreement with our allies. For example, modifying equipment to correct a human factors deficiency may impact heavily on the assembly line of some German manufacturer. Some TSMs have had difficulty explaining to their staff the restrictions imposed by the RSI program.

19. Some LCSMM-related documents that are not now action documents should be so designated.

Some of the key documents developed during the first and second phases of the LCSMM are not action documents. In particular, the preliminary QQPRI is developed and then widely staffed as an information copy. A copy of the PQQPRI is forwarded to MILPERCEN but they are not not required to respond to this copy even if they are aware of potential conflicts between the proposed QQPRI and personnel recruitment plans. As a result, the TSM may develop a final QQPRI that is in conflict with MILPERCEN's perception of the types and quantities of people who can be provided in a future time frame. Such disagreements should be resolved as early as possible, otherwise systems that cannot be adequately manned may be developed.

20. Inaccuracies in Reliability, Availability, Maintainability (RAM) data can lead to conflicts regarding QQPRI's.

The development of a provisional QQPRI depends on the availability of RAM data. These data are obtained from the records of equipment similar to that proposed for the new system. When there are no similar equipments, RAM data are developed on the basis of professional judgment. During Phase I of the LCSMM, available RAM data are almost certain to contain inaccuracies, which can lead to conflicts between CDC, TSMs, and MILPERCEN regarding the composition of a QQPRI. For example, CDC might estimate that certain numbers of persons by MOS will be required to maintain the new system. Based on a Task and Skill Analysis performed either by the contractor or by a TRADOC school, the TSM may have different views regarding the numbers and types of persons required to man the system. To complicate matters further, MILPERCEN may claim that, based on its recruitment projections, it will not be possible to provide the persons required by either the CDC- or TSM-proposed QQPRI. Certain systems are now approaching their final stage of development without having an agreed-upon QQPRI.

21. Better and less cumbersome media selection techniques are needed.

During the development of Individual and Collective Training Plans, and the identification of training device requirements, numerous decisions must be made regarding the best media to employ. The interviewers were told that current media selection techniques are cumbersome and are of doubtful value. There seems to be no standard way by which TSMs or those tasked by TSMs attempt to handle this problem. Some seek assistance from NTDC. Others assign the problem to some group within the Directorate of Course Development. For still other systems, the contractor is responsible for matching training requirements and training media. It appears that the media selection problem arises in part because many people do not know how to employ existing media selection techniques and therefore tend to rely on historical precedent.

22. Validation of SPA material sometimes does not occur until after OT II.

The need for SPA material should be identified during Phase I of the LCSMM, and critical portions of this material should be evaluated during OT I. All SPA material should be available for evaluation during OT II. Apparently this is seldom the case. In many instances SPA material is not available even by OT II. Also, SPA material, especially TEC material, often arrives in an unsatisfactory state and has to undergo extensive and expensive revisions before it can be demonstrated to be effective. It was noted also that there are no good procedures for assessing the readability level of figures, diagrams, and charts.

23. Logistics agencies are sometimes slow to provide inputs to TSMs.

TSMs must coordinate their activities with various agencies. Often this is done through the convening of meetings. Some TSMs reported that logistics agencies tend not to send representatives to such meetings. Therefore, inputs from logistics agencies tend to be untimely and may not even be provided.

24. The definition of Initial Operational Capability (IOC) is unclear.

Some confusion was expressed regarding the definition of IOC. Apparently IOC has been defined as (a) when the first operational piece of equipment becomes available, and also as (b) when the first unit to receive the new equipment becomes operational. TRADOC Regulation 600-4 clearly employs the second definition. If the first definition is used, the training system would have to be developed much more rapidly than if the second is used.

25. Persons assigned to a TSM's staff should be familiar with the general developmental cycle for new equipment.

Some TSMs and their staffs are not familiar with the development cycle for equipment. They noted that this basic knowledge should be required of TSMs. Without it, they will have difficulty understanding the LCSMM and coordinating their training system development activities with equipment development schedules.

26. No satisfactory procedures exist for preserving the "institutional experience" developed within a TSM office.

For most officers, serving as a TSM or a staff member of a TSM office is a one-tour assignment. Generally speaking, each TSM office contains four officers and one civilian clerk-typist, none of whom have had prior experience related to TSM activities, and few of whom have ever had experience related to the development of training systems. Experience developed during a tour in a TSM office is lost unless the TSM and his staff serve overlapping tours with their replacements. In some instances this does occur. The use of civilian aides to staff TSM offices was discussed, but this probably would not help much since civilians also change job positions quite often. The use of overlapping tours seems to be the best way to preserve "institutional" experience.

Another way might be to develop workshops for TSMs, an approach that has been tried with some success. As a third alternative, data and how-to-do-it information could be made available at the local level by means of a management information system. TRADOC plans to develop a CONUS-wide computer-supported management information system makes this a viable alternative. Such a program would allow for immediate update of both procedural and methodological information and encourage the exchange of lessons learned among TSMs.

APPENDIX B

SUGGESTED TOPICS/CONTENT FOR TSM HANDBOOK

1. Backward Planning Guidance

This information would identify the major milestones in the LCSMM and for each describe the documents, studies, and other deliverables which should be prepared by those milestones. If possible, this guidance should include information about lead times, and about who should be tasked to develop specific deliverables. The most important milestones would be the three sets of ASARC/DSARC reviews and the IOC.

2. Proponent Planning Guidance

This type of planning information is somewhat similar to that described above, but would concentrate on identifying for Training and Course Development Directorates the materials they should provide or procure and the dates by which they should be ready for use. Items which proponent schools have to produce/procure include facilities, instructors, students for various testing periods, instructors for OT II, and so on. It is important that proponent schools be made aware of such requirements early enough so that the requirements can be incorporated into their budgeting and scheduling cycles.

3. Information about the Format and Content Requirements of Key Documents

All key documents which must be produced as part of the LCSMM are described in a regulation. Most of the regulations describe format and content requirements in general terms. The interviewees expressed a need for more detailed information about such documents, especially about the topics, questions, and issues that should be addressed. In addition, it was noted that a handbook containing exemplary documents to serve as models would be useful.

4. Guidance Regarding the Preparation/Review of RFPs/Contracts

Typically, someone within a TSM office or within a school directorate will be asked to review or even to prepare certain portions of an RFP or contract. In some instances Mil Standards contain material that can be incorporated into an RFP/contract, and a few documents illustrate how certain requirements should be stated in an RFP. These and similar guidance material should be examined to determine whether additional material should be prepared to cover other contractual

requirements. For example, how should the requirement to develop a preliminary Individual and Collective Training plan or a provisional QQPRI be stated in a contract?

5. Guidance Regarding How to Monitor Contractor Efforts and to Evaluate Contract Deliverables

For certain contractor-developed deliverables, guidance regarding how to evaluate them does exist. For other documents and products, guidance does not exist in a readily usable form. Assuming that in the future contractors will be required to develop most LCSMM-related training documents and products, it seems appropriate to identify those deliverables for which monitoring/evaluating guidance does not now exist, and then to prepare such guidance.

6. Information Describing TSM Involvement with Operational Testing

Some TSMs have had difficulty clarifying their role during OT II. Operational Testing is conducted by OTEA, but TSMs are involved with preparations for OT II, and are responsible for assuring that certain training-related items are available. They also are responsible for assuring that appropriate instructors and/or operators are available at OT II. These and other TSM requirements with regard to OT II need to be clearly established.

7. Guidance Regarding the Role of Other TRADOC Agencies

TSMs are authorized to task other TRADOC agencies, but this tasking authority sometimes is not clearly stated in the TSM charter. In addition, many TSMs seem unclear about the services that can be provided to them by other TRADOC agencies, and the appropriate entry points into these agencies. These and related subjects could be described more specifically in a TSM handbook.

8. Guidance Regarding the Conduct of CTEAs

TSMs are responsible for assuring that CTEAs are conducted. At present it is not clear what the minimum requirements of a CTEA are and how to approach the problem. Furthermore, little guidance exists regarding how to conduct a CTEA. This problem is the subject of ongoing studies. The best approach at present seems to be to rely on past efforts as examples.

9. Guidance Regarding the Rationalization, Supportability, Interoperability (RSI) Program

Certain of our new weapons systems are being developed in cooperation with our allies. The goal is to develop weapons systems which can be supported, operated, and even manufactured by our allies. Under this program a TSM has to prepare a Memorandum of Understanding with representatives of our allies. Any changes made to prototype equipment and critical items of training material must be agreed to by all involved allies. Those TSMs involved with the RSI program noted the need for information about the program. They especially expressed a need for information about what, if any, changes to prototype equipment and training devices/material can be made without consultation with our allies. Though these requirements are on a case by case basis, guidance is needed on the design, economic, and political considerations of such changes.

10. Guidance Regarding How to Assure Consideration of Human Factors during Early Phases of the LCSMM

Efforts to condense the LCSMM cycle, and to develop most training-related material under contract may have the effect of reducing human factors considerations during the first two phases of the LCSMM. At the very least it would seem that those preparing RFPs/contracts should be made aware of the need to examine early equipment concepts and prototypes in terms of potential human factors problems. The RFP/contract should emphasize that the contractor is responsible for assuring that major human factors problems do not exist in prototype equipment. Furthermore, the RFP/Contract should provide for the examination of equipment concepts and prototypes by HEL or some other suitable agency. Information on this subject could be incorporated into a TSM handbook.

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 1 Militærpsykiologisk Tjeneste, Copenhagen
 1 Military Attache, French Embassy, ATTN: Doc Sec
 1 Medecin Chef, C.E.R.P.A. - Arsenal, Toulon/Naval France
 1 Prin Scientific Off, Appl Hum Engr Rsch Div, Ministry of Defense, New Delhi
 1 Pers Rsch Ofc Library, AKA, Israel Defense Forces
 1 Ministerie van Defensie, DOOP/KL Afd Sociaal Psychologische Zaken, The Hague, Netherlands