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AIR FORCE
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TRAINING DECISIONS SYSTEM: DEVELOPMENT OF THE TASK CHARACTERISTICS SUBSYSTEM

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This document summarizes the research undertaken to develop the Task Characteristics Subsystem (TCS), one of four basic subsystems of the prototype Training Decisions System (TDS). The TDS is a computer-assisted decision system that is being developed to aid in planning the what, where, and when of training for Air Force career ladders. The TCS addresses what tasks are required to be trained and where (training settings) to allocate those requirements. This two-component subsystem has first the task of constructing Task Training Modules (TTMs) from Occupational Survey (OS) data. The second component is responsible for allocating TTMs to the various training settings such as formal training, on-the-job training (OJT), and others and determines levels of proficiency achieved by setting. Low-tech, medium-tech, and high-tech methodologies were field-tested for the TTM Construction component. A combination of the medium-tech and high-tech methodologies was successful in producing homogeneous clusters of tasks. When subjected to task analysis, the tasks in these clusters or TTMs revealed similar skill and knowledge requirements. As a result of this effort, new Comprehensive Occupational Data Analysis Programs (CODAPs) clustering programs were developed and have been implemented for operational use. Development of the TTM

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allocation component involved pilot-testing three measures of TTM-by-setting proficiency. Guidelines for applying the procedures developed for both components are addressed in detail. (

SUMMARY

Air Force enlisted training is an extensive and expensive operation. Almost all of the thousands of individuals who enter the Air Force each year undergo some type of technical training for their Air Force specialty (AFS), and most receive some type of advanced technical and military training at various points in their careers. Such training is provided in a number of different settings; e.g., in resident technical courses, in Field Training Detachments (FTDs), via correspondence courses, or through on-the-job training (OJT). Decisions which influence training outcomes are made by a number of Air Force agencies responsible for enlisted personnel utilization and training. Currently, coordination of such training decisions is primarily through AFS-specific Utilization and Training Workshops (U & TWs), but U & TW decisions have tended to focus primarily on initial skills training programs and Specialty Training Standards (STSs). At the request of HQ USAF and Air Training Command, the Training Decisions System (TDS) is being developed as a computer-assisted training decision aid to assist Air Force managers in defining the jobs and training requirements of an AFS, in assessing the possible effects of changing jobs or training programs, and in making better training decisions.

The TDS is composed of four subsystems. The Task Characteristics Subsystem (TCS) identifies groups of related tasks and how they are (or might be) allocated to various training settings to achieve the required proficiency. The Field Utilization Subsystem (FUS) models the jobs and training programs of the AFS as a basis for understanding training requirements, and develops ideas for alternative approaches. The Resource/Cost Subsystem (RCS) develops estimates of AFS training resources and costs, and assesses the capacity of units to provide such training for current and alternative utilization and training patterns. The Integration/Optimization Subsystem (IOS) permits managers to examine the possible consequences of their training decisions in terms of costs or meeting required proficiencies; it will also aid managers in optimizing such training decisions.

The TCS has two components. The Task Training Module (TTM) Construction component was developed by assessing low-technology, medium-technology, and high-technology task clustering methodologies. A combination of medium- and high-technology approaches was selected as an efficient means of developing TTMs. The recommended three-step process involves (a) task clustering using Comprehensive Occupational Data Analysis Programs (CODAP), (b) preliminary interpretation by an analyst, and (c) having subject-matter experts (SMEs) name and refine the task clusters as TTMs. The TTM Allocation component collects SME judgments on how much proficiency can be achieved for each TTM in various training settings, and uses this information to estimate TTM proficiency-by-setting functions. Three measures of proficiency were pilot-tested with two Air Force specialties (AFS 811XX, Security Police; AFS 328X4, Avionic Inertial and Radar Navigation Systems), and the final procedure validated with two additional AFSs (AFS 423X1, Aircraft Environmental Systems; AFS 305X4, Electronic Computer and Switching Systems). Detailed information for applying the procedures developed for both components is presented.

PREFACE

The Task Characteristics Subsystem (TCS) is one of four subsystems of the Training Decisions System (TDS) research and development (R & D) effort. The TDS is a multi-year R & D effort consisting of four major research tasks and is sponsored by HQ USAF/DPPT and HQ ATC/XPC. It is being accomplished under Project 7734 and is being developed to provide a more systematic and integrated approach to training management decisions. For a general overview of the system, see AFHRL-TP-87-25, Training Decisions System: Overview, Design, and Data Requirements. For additional details, see the reports cited in the Reference List for this report.

A project of this magnitude requires the cooperation and dedication of many people. In this respect, we acknowledge Mr. Wayne Archer and Mr. Bill Phalen of the Manpower and Personnel Division for sharing their knowledge of Comprehensive Occupational Data Analysis Programs (CODAP) and expediting the development of new ASCII CODAP task clustering procedures. Mrs. Connie Villarreal of the Information Sciences Division provided advice and expedient programming support when needed. Special thanks go to all the Major Commands and functional staff offices which provided assistance by making available the subject-matter experts who were instrumental in reviewing the TCS data for the AFSs involved in this effort.

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1.0 INTRODUCTION

The Task Characteristics Subsystem (TCS) is one of four basic subsystems of the Training Decisions System (TDS). Its functions within the TDS are (a) to derive groups of Occupational Survey (OS) tasks for an Air Force specialty (AFS) which should be trained together, (b) to specify the setting(s) in which these groups of tasks can be trained, and (c) to estimate the time required to train the tasks in the settings and Air Force managers' preferences for this allocation of training among the training settings. This report documents the research and development of the procedures, software, and instrumentation of the TCS to support these objectives.

1.1 Air Force Training Decision-Making

Training decision-making is a process of balancing, either implicitly or explicitly, a number of separate, and possibly inconsistent, considerations. From an instructional viewpoint, material to be trained should be matched as closely as possible to the instructional media to be used. Some types of content may be imparted through trainee self-study; other topics may require closer supervision and feedback; still other skills may be trained most effectively through hands-on experience and extensive practice. From the viewpoint of the effective utilization of manpower, training should be structured to provide adequate numbers of fully trained personnel where and when required. Changes in the deployment of personnel, technology, and situational demands affect the way work is structured and so, patterns of training. Finally, from a financial perspective, the personnel and resource requirements for providing training may differ substantially from one type of training to another. All other factors being equal, the least expensive training forum is to be preferred.

Ideally, the instructional setting best suited for the presentation of a particular skill or knowledge is also the least expensive and is capable of providing sufficient numbers of fully trained personnel where and when they are required. In practice, instructional, manpower and personnel utilization, and financial considerations must be balanced in deciding who gets trained, when, where, and on what skills and knowledges.

Several Air Force agencies are currently responsible for managing personnel and training; consequently, the present system for planning and decision-making is very decentralized (Mitchell, Sturdevant, Vaughan, & Rueter, 1987). Different managers in Air Training Command (ATC) have direct responsibility for resident classroom training, Field Training Detachments (FTDs), mobile training teams, and Career Development Courses (CDCs). The Military Personnel Center is the Air Force manager for on-the-job training (OJT), and ultimately, every supervisor has OJT responsibilities. Manpower, personnel, and functional policies often have training implications. For example, RIVET WORKFORCE is a major initiative to restructure AFSs to better meet functional requirements. However, such occupational restructuring has major implications for training.

Systematic efforts are being made to coordinate the efforts of these groups. For example, Specialty Training Standards (STSs) serve as contracts between ATC and the major commands concerning what training will be provided in formal resident courses and what will be provided elsewhere. Also, Utilization and Training Workshops have been used to bring together Air Staff and major command functional managers, subject-matter experts (SMEs) from base-level units, Military Personnel Center classification staff, and Air Force training managers, so that coordinated decisions can be achieved. This type of conference provides an interactive decision capability where all viewpoints concerning a specialty can be considered.

Based partially on the success of the Utilization and Training Workshops, Training Planning Teams have recently emerged in the area of training requirements specification and training development. The primary responsibilities of these groups reside in anticipating the training requirements for each stage in the life cycle of a weapon or support system and in Air Force career qualification (see AFR 35-8). Training Planning Team efforts are documented in a Training Development Plan, which serves to guide the development of training for a career field (or new weapon system) for several years into the future. Beyond the development of a formal plan, the team is also responsible for seeing the plan implemented, meeting periodically to review progress and determine if further modifications of the plan are required.

The effectiveness of these activities is limited, however, as the information available to the decision-makers is often fragmentary and nonsystematic. The current pattern of personnel utilization is described by the OS program. Expertise regarding the appropriateness of training a given topic in a particular setting resides with training and functional managers. However, given limited personnel and resource capacities for individual training settings, the tradeoffs of training different skills in particular settings are generally unclear, due to the number of distinct skills and knowledges in an AFS and the number of possible training settings. The associated costs of providing training in given settings are also unknown, as well as the implications of alternative patterns of personnel utilization. Finally, these groups of Air Force managers, with different backgrounds and perspectives, often lack a common vocabulary or way of looking at the issues and potential courses of action.

The TDS and its subsystems will be a means of bringing together information of various types--instructional, personnel utilization, and financial--in a common framework to aid Air Force training decision-makers. It will provide the means to model both the current training system and alternative patterns of job structure and training. It will assess the implications of different manpower and personnel practices and indicate the optimal training pattern given certain types of constraints. In short, it will assist training decision-makers by providing a common vocabulary and integrated information concerning the instructional, personnel utilization, and financial implications of various personnel and training policies.

1.2 Training Decisions System Subsystem Integration

In addition to the TCS, which encompasses instructional concerns, the TDS includes the following subsystems: the Field Utilization Subsystem (FUS), the Resource/Cost Subsystem (RCS), and the Integration and Optimization Subsystem (IOS). In general, the purpose of the FUS is to represent personnel utilization factors. These include descriptions of the current and alternative patterns of personnel utilization and training (U & T) and Air Force managers' preferences for these different patterns. The RCS will be designed to estimate the costs, resource requirements, and resource capacities of different training sites--the financial considerations involved in training decision-making. Finally, the IOS will integrate the products from each of these subsystems, so that the TDS can model or optimize characteristics of the personnel training system.

The TCS produces two major products that will be used in the modeling and optimization of personnel use and training. The first are Task Training Modules (TTMs). TTMs are groups of OS tasks for which it is advantageous to train them together (the exact criteria used to identify TTMs will be discussed in the next section of this report). TTMs are the basic units of analysis used in the TDS. The FUS will describe personnel use (i.e., jobs) and training in terms of the TTMs involved. The RCS will use TTMs as the units for estimating training costs and resource capacities.

The second TCS product is a description of how training on TTMs can be allocated among various training settings, including the classroom, CDCs, FTDs, and OJT (OJT, for the purposes of this study, is all on-the-job experience that is required in order to reach minimum performance standards for the TTMs; it is not limited to the formal upgrade OJT program). This TTM allocation description includes the number of hours of training in each setting that are required, on average, to reach minimum performance standards for each TTM and Air Force managers' preferences for this allocation of training. Training times are used by the RCS in establishing costs and resource capacities. Preferences, on the other hand, are outcomes from the TCS that could be reported for the modeling or optimization of personnel use and training patterns.

Their proposed uses place certain requirements on the TCS products. With regard to TTMs, these task groups should be conducive to the description of the current and alternative patterns of personnel training and job structure in the FUS. However, since the relationship between OS tasks and jobs/training is complex and overlapping, the match between TTMs and U & T patterns will necessarily be approximate. In addition, TTMs should be relevant to a range of different U & T patterns, of which the current pattern is only one.

TTMs should also represent groups of OS tasks which are relatively homogeneous with respect to underlying skills and knowledges and which are relatively distinct from other groups of OS tasks. From an instructional viewpoint, these are tasks which can be trained in the same setting(s). From the perspective of personnel utilization, TTMs of this type can be used to describe current or alternative patterns. And finally, from the financial viewpoint, such TTMs should encompass most of the economies of training that result from common training materials, content, equipment, and the like. Consequently, the associated costs of training are additive across TTMs for many different personnel and training policies.

Use of TTM allocations by the other TDS subsystems also places requirements on these descriptions. Descriptions of TTM training allocations should represent a broad range of the feasible ways of apportioning training among settings. This requirement permits the TDS flexibility in modeling and optimizing patterns of personnel training. The primary restriction on each TTM allocation is that the training provided in all of the settings be sufficient to permit the average airman to perform the tasks in the TTM to minimum standards; that is, the TCS is responsible for setting the lower bound for training times for modeling or optimization. Given that the times are adequate, on average, the RCS can use the allocations to estimate training cost.

The TCS is divided into two components according to these two primary products -- the TTM construction component and the TTM allocation component. Research and development (R & D) of these components is described in the next two sections of this report. The work discussed in these two sections is based on R & D in four AFSs--811XX, Security, Law Enforcement, and Law Enforcement-Military Working Dog Qualified Career Ladders; 328X4, Avionic Inertial and Radar Navigation Systems Career Ladder; 305X4, Electronic Computer and Switching Systems Career Ladder; and 423X1, Aircraft Environmental Systems Career Ladder. In the final section, directions for future research in TCS methodologies are discussed.

2.0 TASK TRAINING MODULE CONSTRUCTION

The requirements that TTMs be appropriate for describing patterns of personnel utilization and training (both resident and field training), and that they encompass economies of training tasks together, imply two general characteristics of TTMs: They should be composed of tasks that share skill and knowledge requirements, and they should tend to be performed by the same personnel in the field (although, not necessarily at the same time). The latter characteristic, co-performance, captures efficiencies of training tasks in the field, for example, in FTDs or through OJT; and these same efficiencies may be important for resident training and CDCs. The characteristic of common skill and knowledges assures that instruction on sets of similar tasks in any setting can be accurately represented, so that economies such as those resulting from shared resources or transfer of learning are taken into account. To the extent that the characteristics of homogeneity of skills and knowledges and co-performance are met, the TTMs formed should be meaningful to TDS users and should be useful for training decision-making.

Two TTM construction methods were field-tested in AFS 811XX and AFS 328X4--statistically clustering OS tasks based on co-performance and SME task sorting (several similarity measures were evaluated in addition to co-performance, and techniques other than statistical clustering and task sorting were evaluated; see Perrin, Vaughan, Yadrick, Mitchell, & Knight, 1986, for more details). These TTM construction methods were selected for field test because of their sensitivity to co-performance and to skill and knowledge homogeneity requirements. The field test of these methods is discussed in the section that follows. A more complete account of the

R & D of the TTM construction methods is available in Perrin, Vaughan et al. (1986). From the results of those field tests, a procedure based on these techniques was developed and applied to AFS 423X1 and AFS 305X4. In the second section, this recommended procedure is described, along with the results of applying it to the two new AFSs. Perrin, Mitchell, and Knight (1986) provide a more thorough description of this work. Guidelines for using the recommended procedure are detailed in Appendix A.

2.1 Development of TTM Construction Methods

2.1.1 Statistically Clustering OS Tasks

Statistical clustering has a long history in military occupational analysis. For more than 30 years, Air Force job analysts have used case (person) cluster diagrams to assist in identifying jobs--groups of personnel performing similar sets of tasks. Over that period of time, standardized data collection instruments (OS task inventories) have been developed and refined, computing algorithms and diagnostic statistics have been devised and tested, important background characteristics have been identified and incorporated into the analysis of the structure of work, and an extensive body of research and application has accrued (Christal, 1974; Mitchell, Ruck, & Driskill, 1988). By comparison, the notion of statistically clustering tasks to support training decision-making is relatively new. Nonetheless, existing OS data and Comprehensive Occupational Data Analysis Programs (CODAP) algorithms proved suitable for testing this approach for TTM construction.

The statistical clustering algorithm that has been applied to job typing and is utilized in CODAP is the average linkage clustering procedure (Ward, 1963). This procedure has performed well in empirical studies that have compared various clustering algorithms (Milligan, 1981; Mojena, 1977), and consequently, it was selected as the algorithm to use for task clustering. Similarity indices that were field-tested were of two general types--co-performance similarity and similarity based on task characteristics. In general, task clusters based on the co-performance similarity measure more nearly met the requirements for skill/knowledge homogeneity and co-performance than the clusters based on the other similarity measures; consequently, only the research on co-performance is discussed in this report.

TTMs based on OS task co-performance clustering tend to produce groups of tasks that are performed together; that is, if an airman performs one task in the group, it is likely that he or she also performs others in the same group as part of his or her job. Figure 1 illustrates the relationship between case (or person) clustering (the usual application of CODAP to job typing) and task clustering (the application to identify tasks that are performed by the same personnel). (Note that job typing normally uses a relative time spent measure for clustering cases rather than the performed/not performed dichotomy depicted in Figure 1; in normal job typing, a number between 0 and 1 representing relative time spent on a task would replace the 1's in the figure.) While job typing involves grouping persons who perform the same (or similar) sets of tasks, task clustering produces sets of tasks which are frequently co-performed.

JOB TYPING: CLUSTERING PERSONS WHO PERFORM THE SAME (OR SIMILAR) SETS OF TASKS

		TASKS								
PERSONS		1	2	3	4	5	6	7	8	9
JOB I	1	1	1	1						
	2	1	1	1						
JOB II	3	1	1	1	1	1	1			
	4	1	1	1	1	1	1			
JOB III	5				1	1	1			
	6				1	1	1			
JOB IV	7							1	1	1
	8							1	1	1

TTM CONSTRUCTION: CLUSTERING TASKS THAT ARE PERFORMED TOGETHER

		PERSONS							
TASKS		1	2	3	4	5	6	7	8
TTM I	1	1	1	1	1				
	2	1	1	1	1				
	3	1	1	1	1				
TTM II	4			1	1	1	1		
	5			1	1	1	1		
	6			1	1	1	1		
TTM III	7							1	1
	8							1	1
	9							1	1

Figure 1. The Relationship Between Case Clustering for Job Typing and Task Clustering for TTM Construction.

2.1.2 SME Task Sorting

Perhaps one of the most straightforward ways to classify information is simply to have people sort examples into categories. One such approach is to print examples on cards and have people sort these cards; the piles that result constitute the categories. This procedure has a long history in psychology for research in cognitive modeling, and seemed suitable for use in forming TTMs from OS tasks.

To make the job of sorting all of the OS tasks of a specialty more manageable, some initial structure in the form of starter piles was provided. These initial piles were not to limit the sorting of tasks in any way, but merely to provide groups of manageable size based on reasonable divisions of the subject matter. Two types of starter piles were used in the field tests: one based on STS paragraph references and a second based on co-performance clustering (as described previously).

In addition to the initial structuring of the task, the background of the SMEs might influence the groupings produced. Specifically, resident technical trainers and field personnel might have different points-of-view regarding the similarity of tasks for training purposes. Consequently, separate groups of SMEs, one composed of technical trainers and one of field personnel, were used to sort each set of starter piles. The four groups involved in the field tests can be identified by their type of starter pile and their background as follows: STS/school; STS/field; co-performance/school; and co-performance/field. The TTMs produced in four independent card sortings permit pairwise comparisons between different initial structures and groups of SMEs with different training perspectives.

The groups of SMEs were directed to rearrange the cards into piles that represented groups of tasks that should be trained together. The directions to the SMEs stressed the importance of using their expertise in forming the TTMs, and the instructions specifically noted that the resulting piles might include duplicate tasks and be of any size, including single tasks. The groups of SMEs worked independently to sort the cards into TTMs, proceeding at their own pace and using their own strategies to complete the task.

When each group was satisfied with their task groupings, two groups met to reconcile any differences between their groupings. This reconciliation phase allowed the groups to compare strategies used to form the TTMs, decide upon the best criteria, and produce a final set of task clusters. The two sets of reconciliation sorts provided independent replication of the results.

In AFS 811XX, all four groups sorted the tasks into TTMs. Then, the co-performance/field and co-performance/school groups met to create one reconciliation sort, while the STS/field and STS/school groups formed the other reconciliation sort. Attempts to convene a group of field SMEs for AFS 328X4 were unsuccessful, and so, only two groups were formed: STS/school and co-performance/school. These two groups then met to form a reconciliation sort in AFS 328X4.

2.1.3 TTM Construction Field Test Results

Consensus judgments of sizable groups of SMEs concerning the tasks in their specialty that should be trained together are perhaps the best criteria for TTM construction methods. This approach, since it was designed to facilitate maximum expression of the participants' expertise in grouping tasks, is both a TTM construction method and a standard against which other construction methods can be compared. Additionally, however, TTMs identified from a task co-performance cluster diagram represent an important criterion--co-performance. Fortunately, results from the field tests in AFS 811XX and AFS 328X4 indicate that these approaches to TTM construction are consistent and complementary.

The Fowlkes and Mallows (1983) statistic was used to indicate the consistency of task grouping results. This statistic ranges from 0, when no two tasks were grouped together in both of the two solutions being compared, to 1, when the two solutions are identical. The Folkes and Mallows statistic will exceed 0.044 in only about one percent of the cases by chance alone, given the number of tasks being sorted and the number of groups being formed.

The SME task sortings were quite consistent. The average Folkes and Mallows statistic for the comparisons among the different 811XX task groupings was 0.264, and ranged from 0.199 to 0.304. Since there were only two 328X4 groups, there was only one independent comparison; the Folkes and Mallows statistic for that comparison was 0.476. Clearly, there was a core of task groupings about which the experts agreed quite closely.

After an analyst had identified TTMs from the task co-performance cluster diagram, these groupings were compared to the SME task sortings. Significantly, the overall level of agreement between the SMEs' card sorts and the task co-performance clusters tended to be as high or higher than the agreement between different groups of SMEs. In AFS 328X4, the average level of agreement between the co-performance clusters and the SME sortings (as indicated by the Folkes and Mallows statistic) was 0.247. For AFS 811XX, the Folkes and Mallows statistic averaged 0.428 for the same comparisons. Taken together, these findings suggest that the similarities in tasks that result in frequent co-occurrence in performing one's job are important considerations in determining what tasks should be trained together. Apparently, the co-performance clusters captured the core of agreement in the SMEs' judgments. This conclusion must be qualified, however, as a significant number of tasks in both specialties (115 for 811XX and 35 for 328X4) could not be classified by the analyst, based solely on the co-performance cluster diagram.

The type of starter pile used in the card sorting exercise (co-performance or STS paragraph) had no appreciable effect on the results. The background of the SMEs (school or field) apparently did influence the solution. Field SMEs' TTMs more closely matched the co-performance clusters than did the school SMEs' sortings. Also in AFS 811XX, the results from the two field groups showed the highest level of agreement, and the reconciliation sorts were more similar to the field SMEs' solutions than to the school SMEs' TTMs.

In addition to the consistency of results obtained using different TTM construction methods, the relative costs and flexibility of the approaches were considered. Task co-performance clustering is a relatively efficient and cost-effective method of contructing TTMs. The basic routines for task clustering have already been implemented in a rewrite of CODAP for the Air Force (called ASCII CODAP in the rest of this paper; see Phalen, Weissmuller, & Staley, 1985, for an overview of ASCII CODAP). Operational costs would be largely limited to computer charges for compiling the task cluster diagram and an analyst's time in interpreting it.

Unfortunately, the clustering procedure has some limitations in its flexibility for constructing TTMs. Specifically, the current clustering procedure does not allow for the assignment of a task to two or more TTMs, a situation that might be of value in certain situations. Additionally, it is sometimes difficult to assign a task to a group based solely on a cluster diagram. (In job typing, it is common to have from 10% to 20% of the cases unclassified.) A new, nonhierarchical clustering algorithm holds great promise for reducing or eliminating these difficulties (Mitchell & Phalen, 1985); however, this procedure is not yet fully operational, and so, complete evaluation of its usefulness for the TDS cannot yet be determined.

On the other hand, SME card sorting is more flexible than co-performance clustering. The instructions for card sorting were written to permit maximum flexibility in structuring TTMs. Emphasis was placed on using one's expertise in forming modules of tasks that should be trained together, and the possibility of using duplicate tasks for this purpose was specifically mentioned.

The costs associated with SME card sorting can be rather high, however. Results from the field tests indicate that (a) multiple groups of at least three SMEs (more if the specialty is diverse) should be involved, and (b) at least one group should be composed of field SMEs. Given the requirement for multiple SME groups composed of both school and field personnel, and considering that card sorting required a minimum of 2 days (3 if a reconciliation sort was produced), arranging for card sorting in any particular specialty may be difficult and costly. These difficulties will apparently be compounded for highly specialized career fields, when personnel are dispersed geographically, or when workload is high.

2.2 Recommended Procedure

The TTM construction methods of co-performance clustering and SME card sorting were found to have both strengths and weaknesses. The recommended procedure of co-performance clustering, followed by SME refinement, capitalizes on the strengths of both methods, while avoiding many of the pitfalls. This procedure was applied to TTM construction for AFS 305X4 and AFS 423X1. The results described in this section reflect the validation work in these two specialties.

The recommended TTM construction procedure involves three steps as follows:

1. statistically cluster OS tasks for the specialty using co-performance as the similarity measure;

2. interpret the co-performance cluster diagram, identifying initial TTMs based on patterns of between and within group homogeneity; and

3. have SMEs in the specialty name the task groupings, place tasks that could not be grouped based on the clustering results, and refine the initial clusters to form final TTMs.

The discussion of this validation work is organized around these three steps. First, the method of task co-performance clustering is described. Then, training for cluster diagram interpretation and comparisons of three independent interpretations for each specialty's cluster diagram are summarized. Third, steps for SME review of the initial TTMs are discussed, and these final clusters are compared to the initial groupings. In each of these sections, the personnel and resource requirements for applying the procedure are noted. In the final section, the internal consistency of TTMs and their distinctiveness, one from another, have been assessed by using task analysis.

2.2.1 Co-performance Clustering

The first step in the recommended TTM construction procedure is to statistically cluster the OS tasks in the specialty. Task co-performance clustering is supported in ASCII CODAP. The first step in producing a task co-performance cluster diagram is to transpose the case data file using a routine called XPOSE. This routine, as the name implies, converts the file from a case-oriented to a task-oriented form. Rather than task performance data for each respondent, the file is composed of respondent performance data for each task. A practical limitation is imposed by this approach in that the number of cases effectively becomes the number of tasks in the transposed file, and ASCII CODAP is limited to 3,000 tasks (transposed cases) that can be clustered at one time.

Sample sizes for 305X4 and 423X1 were less than this limit, however, so XPOSE was used to transpose the case data files. The XPOSE control cards specified the "raw task responses" transpose of the file. Then, clustering was performed using the regular sequence of OVRLAP, GROUP, and DIAGRM, specifying the co-performance option in the OVRLAP routine. Finally, the OS tasks can be linked to TPATH (KPATH) numbers, so that the groups can be interpreted by studying the tasks in TPATH order (PRTVAR).

Since the completion of this research, several additional CODAP products that support interpretation of task cluster diagrams have been developed by Texas Maxima Corporation under contract with AFHRL. Phalen, Staley, and Mitchell (1987) discuss some of the new routines that have been developed for this purpose.

The cost of this TTM construction step has been estimated to be approximately $300 to $350 per specialty, plus computer charges. Undoubtedly, this step will become more costly and time-consuming as additional TTM-relevant programs are added to CODAP; however, the quality of the resulting interpretations should increase as well, potentially reducing costs for later TTM construction steps.

2.2.2 Cluster Diagram Interpretation

The second step in the recommended TTM construction procedure is to interpret the task co-performance cluster diagram. For the purposes of the validation work in AFSs 305X4 and 423X1, two AFHRL analysts were given 3 days of training on this task. The content of the training was as outlined below:

1. Orientation to Hierarchical Clustering
    - a. Discussion of Air Force occupational analysis
    - b. Examination of the OS task inventory for AFS 423X1
    - c. Walk-through of the AFS 423X1 cluster diagram
    - d. Examination of the AFS 423X1 OS Report
    - e. Discussion of AFHRL data files (e.g., Occupational Research Data Base reports, OS Reports)
    - f. Discussion of the co-performance similarity measure
    - g. Discussion of the new version of CODAP

2. Walk-through of TTM Construction in AFS 328X4
    - a. Examination of new CODAP cluster diagram format
    - b. Criteria for initial TTM selection and use of PRTVAR
    - c. Examination of booklets used by SMEs to refine TTMs
    - d. Discussion of TTM review by SMEs in AFS 328X4
    - e. Second review of cluster diagram in light of SME results
    - f. Final TTMs and their uses in TDS

3. Practicum -- Analysis of AFS 423X1 diagram
    - a. Handout copies of AFS 423X1 task cluster diagram
    - b. Handout copies of AFS 423X1 PRTVAR
    - c. Discussion of criteria and approach to analysis (including need for independent analyses)
    - d. Analysis of diagram (with assistance as required)

4. Comparison of Results
    - a. Review of exercise goals and status
    - b. Completion of TTM listings
    - c. Comparison of outcomes (in terms of number and general size of initial TTMs identified)
    - d. Discussion of agreement and differences

Following training, the two AFHRL analysts and contractor personnel independently interpreted the AFS 423X1 and AFS 305X4 task co-performance cluster diagrams. Although the interpretations differed somewhat in the specificity of the initial TTMs identified (some analysts favoring broad TTMs with many tasks; others preferring smaller, specific TTMs), the interpretations of the diagrams were highly consistent. The average Folkes and Mallows statistic for all comparisons between different solutions for AFSs 423X1 and 305X4 was 0.89.

Estimates of the cost of the initial training for the analysts were about $800 per trainee. With the limited number of computer products that were available to support initial TTM identification, analysis of task cluster diagrams would probably vary from about 3 to 10 days, depending on the complexity of the specialty. The associated personnel costs would range from about $380 to $1,300 per specialty. Again, this cost will undoubtedly grow as the TTM identification process is refined and additional computer products are developed.

2.2.3 SME Refinement

The final step in the recommended TTM construction procedure is to have a representative group of SMEs review, name, and refine the initial TTMs. In this step, care should be taken to select an adequate group of SMEs to represent all important aspects of the career field (weapon system, major command, type of equipment, etc.). Additionally, earlier research (discussed in section 2.1.3) indicates that these SMEs should be selected from both training and field personnel, as the perspectives of these two groups may differ.

Objectives of this refinement step are threefold. First, the SMEs should name each TTM with a title that, as clearly as possible, communicates the content of the module. This process apparently helps the SMEs identify the common theme among the tasks and so highlights inappropriately grouped tasks. A clear TTM title will also be invaluable for communicating content in later surveys and for making the final TDS easy for users to operate. The second objective of the refinement step is to add or delete tasks from TTMs to form the most cohensive and distinctive groupings possible. Finally, SMEs should group the tasks that could not be classified by the analyst based on the co-performance cluster diagram. This may mean forming new TTMs or simply adding these tasks to existing modules.

Of special interest is the 423X1 TTM refinement, since this list of TTMs was completely reviewed twice, once at Randolph AFB and once at Tinker AFB. In the first refinement, the SMEs tended to favor more specific TTMs than two of the three analysts, forming 73 TTMs. The second SME refinement resulted in a broadening of the TTMs, as the SME combined task groupings to form 58 final task modules. It is interesting to note that often the SMEs' TTM divisions and combinations could be directly linked to the original cluster diagram. Results from comparing the initial TTMs (analyst's interpretations of the cluster diagram) and the SME refinements using the Fowlkes and Mallows agreement statistic indicated that analysts tend to agree with analysts more closely (average Fowlkes and Mallows of 0.89) than they agree with the SME reviews (average Fowlkes and Mallows of 0.58). Additionally, the two independent SME reviews in AFS 423X1, while differing in level of specificity, agreed quite closely with each other (Folkes & Mallows of 0.87). In short, analysts' interpretations of cluster diagrams are consistent with but not equivalent to SME-formed TTMs; thus SME review is an important step in creating stable, meaningful task groupings.

Costs incurred in the SME refinement step would include the salaries of the SMEs and support personnel involved. The number of SMEs will vary with the diversity of the specialty. Three to five SMEs appears sufficient in career fields with simple structures; twelve to fifteen SMEs should be sufficient for all except perhaps the most diverse specialties. For a complete review, especially if this is the first and/or only review, 1 day of SME time should be allotted. Given these factors, personnel costs for refinement might range from roughly $350 to $1,700, again depending on the complexity of the specialty. Travel and housing expenses, if required, would have to be added to this figure to arrive at a total cost for TTM refinement.

Using figures cited earlier for task clustering, diagram interpretation, and SME refinement, the total costs for TTM construction should range from about $1,030 in simple AFSs to $3,300+ for a very complex specialty. These figures do not include initial analyst training cost (see section 2.2.2), nor do they include computer charges (other than programmer time) or SME and/or TDS personnel travel and housing expenses.

2.3 Task Analysis

An important requirement of TTMs is that they should represent relatively independent and distinct areas of subject-matter knowledge and procedural skills, so that TTM training costs will be additive. An additional important characteristic is that they contain related tasks, so that training content can be clearly and unambiguously communicated during data collection and to users of the final system. A test that reflects both the distinctness and internal consistency of TTMs is task analysis. The requisite knowledges and procedural skills, as indicated through task analysis, should be more similar for tasks within a TTM than for tasks from different TTMs. Overall, task analysis indicated that the tasks within a TTM were more similar than tasks from different TTMs, further supporting the validity of the recommended TTM construction procedure.

Two sources of information guided the task analysis work: the Task Analysis Handbook (AFHRL-TR-79-45; see Eschenbrenner, DeVries, Miller, & Ruck, 1980, and DeVries, Eschenbrenner & Ruck, 1980), and the draft Training Development Service (USAFOMC/OMT) Procedures Guide, Chapter 8.0, Task Analysis.

Four SMEs were interviewed at two separate locations for each specialty. All SMEs interviewed were extremely well qualified in their respective career fields. Four TTMs were selected by AFHRL personnel in each specialty for task analysis. However, only three of these were analyzed by the 423X1 SMEs, due to time constraints. The procedure followed for each TTM was to present the SME with an individual task from the TTM, and then have that SME complete a four-part, five-page task analysis worksheet developed by the USAF Occupational Measurement Center.

The task analyses of the tasks within TTMs indicated that the TTMs tend to be both homogeneous with respect to the requisite skills and knowledges and distinct from other TTMs. For several TTMs, the equipment required, the environment, and the references were all very similar or the same for all of the tasks in the TTM. By contrast, some of the TTMs selected for task analysis included preventive maintenance inspection (PMI) tasks, including one TTM which contained only one task. Such tasks, by their very nature, require a variety of skills and knowledges, especially when an entire system or subsystem of equipment or test equipment is involved. The question of whether these PMI tasks should stand alone or be incorporated into the TTM for the system/subsystem is one of the specificity of the module--an issue on which, as was noted previously, even the experts do not always agree.

2.4 Conclusions

The primary issue raised by this validation work is not one of the adequacy of the TTM construction procedure itself; rather, the primary issue is one of the appropriate level of specificity for TTMs. In interpreting the task co-performance cluster diagram, it was a question of 'how far down the diagram' one chooses initial TTMs. In the refinement step, SMEs were found to differ in the degree of specificity they believed was appropriate. In task analysis, the problem was encountered in the form of the placement of PMI-type tasks. Furthermore, this problem seems to be more severe for management and supervisory tasks than for technical tasks; that is, there appears to be less agreement as to the appropriate level of specificity for TTMs that cover management/supervisory tasks compared to technical tasks. But, as has been noted elsewhere (Perrin, Vaughan et al., 1986), choice of a level of specificity is strongly influenced by the ultimate uses for the TDS. Broader TTMs capture efficiencies from training these tasks together, whereas more specific TTMs may yield clearer pictures of personnel utilization patterns. Clearly, implementation of the system using a good approximation of TTMs will aid in identifying the characteristics that TTMs should possess to be maximally useful for Air Force training decision-aiding.

The validation work conducted in 423X1 and 305X4 indicates that the recommended TTM construction method produces good first approximations of TTMs. The comparisons among independent interpretations of the task co-performance cluster diagram, the comparisons among independent SME refinements of the initial TTMs, the comparisons among the initial and refined TTMs, and the task analysis of selected TTMs all support the acceptance of the recommended TTM construction procedure as a reliable and valid technique for task clustering. Statistically, all of the comparisons made have been highly significant. Practically, the procedure produces results that experienced personnel in the various career fields believe capture training efficiencies, and does so in a timely and cost-effective manner.

3.0 TASK TRAINING MODULE ALLOCATION

This section describes the R & D of the TTM allocation component, the second of two components of the TCS. The purpose of the TTM allocation component in the TDS is to provide descriptions of alternative ways of allocating training among classroom instruction, correspondence courses, field training groups, and OJT. The allocation component should be capable of describing the current allocation of training on a TTM among these training settings and the "most preferred" allocation of training, as well as a broad range of other possible alternatives. The chief restriction on any TTM allocation is that the training provided in all of the settings be sufficient to permit the average airman to perform all of the tasks in the TTM to an acceptable level (able to perform the tasks with a minimum amount of assistance and supervision). For the purposes of the TDS, this just-able-to-perform level of proficiency was defined as the minimum training standard for TTMs.

Two conceptual issues arise from the requirement that allocations faithfully represent programs capable of providing training to a minimum proficiency level. First, what is the best method of describing training settings to facilitate gathering allocation information from SMEs? And second, what type of measure should be used to describe an amount of training in a setting? The first part of this section discusses the pilot-testing that was conducted to address these questions. In the second part, the results of applying the selected TTM allocation methodology are described. The next section discusses a preference estimation procedure that is based on the allocation survey results. Finally, issues of resource requirements to apply the selected allocation methodology are considered.

3.1 Development of TTM Allocation Procedures

Perhaps the thorniest issue faced in the development of TTM allocation methods was the selection of a measure to describe proficiency gains from training in each setting. The TDS Statement of Work (SOW) called for "...module estimates as to the level of proficiency recommended for each TTM or task within each setting...." (p. 13). In addition to proficiency levels for each TTM by setting, training times by setting must also be obtained, for use in the estimation of training costs.

Major research programs are underway throughout the armed forces to develop reliable and valid performance measurement techniques. Much of this work relies heavily on detailed task analyses and identification of the specific skills and knowledges needed to perform particular tasks. Such analyses would provide a wealth of information concerning the proficiency gains that might be expected with a given amount of training of a particular type. When such information is available, the TDS may be able to incorporate it into the TTM allocation component. In the short term, however, the work documented in this report suggests that TTM-by-setting proficiency estimates can be gathered efficiently by survey and that these estimates are sufficiently consistent to be of considerable value to the users of the TDS.

Three measures of TTM-by-setting proficiency were proposed and pilot-tested. The first was a six-point proficiency rating scale, anchored with "the trainee can perform no aspects of the task independently, requires constant direction" to "the trainee can perform all aspects of the tasks to minimum standards without direct supervision." This rating scale equated partial proficiency with partial mastery of various aspects of the tasks in a TTM and the level of supervision required. SMEs were also required to provide estimates of the number of hours of training needed to achieve the rated level of proficiency in each training setting.

The second measure of proficiency proposed and field-tested was a direct estimate of the percentage of full proficiency achieved in a setting. Full (100%) proficiency for the purposes of the questionnaire was defined as "able to perform the tasks to minimum acceptable standards without direct supervision." SMEs were to then indicate the percentage (0 to 100) that is currently or should be provided in a training setting and the number of hours required to achieve that level of proficiency.

The third and final proficiency measurement approach was to estimate proficiency from the training time estimates provided by SMEs. Each allocation of training time to the settings provides an estimate of a training program that is sufficient to train the average airman to minimum standards on the tasks in the TTM. A series of these allocations provides a set of simultaneous equations that could, theoretically, be solved using simple algebra. Each estimate, however, will have some error associated with it, and so, statistical methods of estimating those equation parameters were proposed.

The second conceptual issue in the development of a TTM-to-setting allocation methodology was how best to describe training settings. The current training settings (e.g., FTDs, CDCs, basic or advanced courses) could be used. There are, however, several complications to using these actual training settings. First, there is variation among AFSs as to the training settings used. Second, having SMEs rate proficiency gains or training times in actual training settings may interfere with estimating the same numbers for alternative allocations. What is of interest in alternatives to the current allocation are proficiency gains or training times using, for example, a restructured CDC or a new FTD.

As an alternative to using actual training settings, a categorization of types of training was proposed and field-tested. The types of training were as follows:

Classroom instruction involving lecture/discussion and related reading (most resident technical training).

Correspondence courses, self-paced, individual study from text (all CDCs).

Hands-on experience in small, supervised training groups using simulators, mockups, or actual equipment (most FTDs).

Hands-on experience on the job including observing others, practicing the tasks, and receiving direction (qualification and upgrade training).

In addition to these three methods of estimating proficiency and two ways of describing training settings, two different questionnaire formats were proposed. One format put all of the different types of estimates for a TTM on a single page. In the field-tested questionnaires, this included four different estimates: (a) the current allocation, (b) the ideal allocation, (c) the minimum entering background, and (d) the maximum training level. The current allocation was to describe the present training program, while the ideal indicated how the SME believed training should be allocated. The minimum entering background was the level of knowledge (if any) an airman should have before beginning training in each setting. Finally, the maximum training level was the proficiency that could be effectively reached in a setting. The alternative format was to separate the different proficiency estimates into different sections of the questionnaire.

The first field test of the TTM allocation procedures was conducted in AFS 811XX at Lackland AFB, TX. The two allocation booklets completed by the AFS 811XX SMEs both used the actual training settings and the format in which all ratings appeared on a single page. They differed by the method of measuring proficiency: One used a proficiency rating scale; the other used a percent of full proficiency achieved. Examples of the survey formats are shown in Appendix B. The results of the field test can be summarized as follows:

1. The SMEs were not comfortable using either measure of proficiency.
2. Training time estimates, which were given in conjunction with the proficiency estimates, were considered difficult judgments, but were meaningful.
3. The questionnare format, which required multiple different types of judgments on a single page, was found to be confusing.
4. Estimates of minimum entering background were largely invariant and generally not important in making allocation decisions.
5. The use of actual training settings interfered with proficiency estimation.

In particular, the SMEs cited difficulties estimating an ideal allocation using existing training formats. For example, how could the existing career development course (CDC) yield more (or less) proficiency than was achieved under the current system?

With this feedback, the TTM Allocation Questionnaire was revised. In the third version, SMEs were to provide only training time estimates, so proficiency could be statistically estimated. The minimum entering background estimates were omitted and different types of judgments (current allocation, ideal allocation, and maximum training) were separated into different sections of the questionnaire. Finally, types of training, rather than the actual training settings, were used; the instructions were revised; and examples of ratings were included.

This questionnaire was taken to Keesler AFB, MS, and was field-tested in AFS 328X4. Overall, the questionnaires were well received. Training time estimates were familiar measures for the SMEs to work with, and although the task was considered to be difficult, the SMEs indicated it was manageable.

3.2 Deriving TTM Allocation Functions

To make the task of estimating TTM-by-setting allocations more manageable for the SMEs, the TTMs for each specialty were grouped into allocation booklets, based on similar functions. The groupings were provided by SMEs; where the groupings were too large for a single booklet, the group was subdivided based on OS duty categories, or arbitrarily, to form two booklets covering the same general topic.

With the exception of one face-to-face administration in AFS 811XX which was used to refine the administrative details of allocation surveying, all of the questionnaires were mailed to the SMEs. Addressees were identified based on their responses to the most recent OS, which indicated they had performed particular TTMs. Only E-4s and above were sent surveys. The surveys were grouped by base and sent to the base's Survey Control Officer, with the instructions that if an SME had departed, the survey was to go to the SME's replacement (by position title).

The reliability of the allocation judgments was estimated from the proportional amount of the total rating variance accounted for by TTMs within each training setting. Omega squared (Keppel, 1982) provides an index of this proportion of variation explained. Omega squared will be 0 when none of the rating variance is explained by TTMs, or equivalently when there is no variation in average training time from TTM to TTM. It will be 1 when all of the rating variance is explained by TTMs, or equivalently when each individual judgment for a TTM is the same as every other judgment. The size of the error component effectively limits the size of Omega squared, since Omega squared can be thought of as the ratio of TTM variance to the sum of TTM plus error variance. Consequently, Cohen (1977) has argued that an Omega square of 0.15 or more is a "large" effect in social science and behavioral research, whereas an Omega squared of 0.06 is a "medium" effect. Although these cutoffs are admittedly arbitrary, they do give some perspective to the interpretation of Omega squared. Additionally, it should be noted that R(11) in the CODAP program REXALL (CORREL in ASCII CODAP) is Omega squared.

Across the four specialties studied, some trends in the patterns in the reliabilities of allocation judgments can be discerned. First, it might be expected that the reliabilities for the current allocation would be higher than those for the most preferred allocation or the maximum training time. After all, the latter two judgments should be subject to individual preference, while the current allocation is a matter of objective reality. This expectation was not supported, however. Overall, reliabilities of the most preferred allocation and maximum training times were about the same (both with average Omega Squared values of 0.109) as that for the current allocation (average Omega squared of 0.101).

Across the different allocations, judgments of the time spent in correspondence/self-study courses showed the lowest reliabilities, with an average Omega squared of 0.087. Work experience time ratings were somewhat more consistent than self-study ratings, with an average Omega squared of 0.091. Classroom and field training group times showed the highest reliabilities overall. The average Omega squared for classroom ratings was 0.126, while that for field training group times was 0.121.

When an SME specifies a set of training times that he or she believes are sufficient to train the average airman to minimum standards for a TTM, a function relating training hours to proficiency is defined. For example, if an SME indicates that 10 hours in the classroom and 12 hours on the job are necessary to reach minimum standards, these data can be represented as:

$$\begin{gathered}10 \text{ class-hours} + 12 \text{ work-hours} + 0 \text{ self-study-hours} + \\ 0 \text{ field-training-hours} = 100\% \text{ of minimum standards.}\end{gathered}$$

Each allocation questionnaire respondent provided two allocations of this type, one for current training and one for the most preferred allocation. In addition, each respondent indicated how long it would take to train a TTM in each of the settings (e.g., in 100 hours on the job) so that the average airman would have reached minimum standards. These data can be represented by the following equation:

100 work-hours + 0 class-hours + 0 self-study-hours +
0 field-training-hours = 100% of minimum standards.

Of course, complete training cannot always be provided in each individual training setting. For example, many TTMs cannot be completely trained in the classroom or using correspondence courses. In the cases in which complete training cannot be provided in a setting, the respondent was to indicate the maximum percentage of full proficiency that could be achieved in the setting and the time taken to reach that level. Thus, each questionnaire respondent provided six allocation judgments for each TTM: four that related the maximum training time in a setting to the proficiency level reached, one for the current allocation, and one for the most preferred allocation.

It was hypothesized that proficiency gain from training in a setting would be greatest initially and would decline as more training was provided in that setting. Eventually, there would be no more gain from providing training in that setting. Thus, the predicted relationship between proficiency and time in a training setting is that of initial gain followed by proficiency leveling-off, a negatively accelerated curve. This general relationship is depicted in Figure 2. The curves in Figure 2 are not those for any particular TTM; rather, they only illustrate the expected form of the relationship. This relationship can be modeled by the following polynomial regression equation:

Proficiency' = a * class-hours - b * class-hours**2 +
c * self-study-hours - d * self-study-hours**2 +
e * field-training-hours - f * field-training-hours**2 +
g * work-hours - h * work-hours**2,

where "a" through "h" are coefficients to be estimated by multiple regression, **2 indicates squaring, and the regression equation is constrained to pass through the origin (there is no constant for the Y intercept).

This model involves specific hypotheses about the nature of the relationship between setting training hours and proficiency. Specifically, controlling for training in each of the other training settings, the first-order parameter is specified to be positive and the second-order parameter is negative, yielding the predicted negatively accelerated curve. Across the four AFSs studied, this statistical model was strongly supported. Statistical estimates consistent with the polynomial regression equation were found in well over 90% of the TTM allocation curves in all four specialties. There are two additional sources of support for the conceptualization of proficiency gain as a negatively accelerated function of training time in a setting. First, the overall fit of the polynomial regression model was found to be quite good, averaging over 65% (multiple R squared) in AFSs 423X1 and 305X4. Second, the additional variance explained by the second-order terms in the allocation equations was substantial (approximately 15% increase in R squared for these specialties), indicating that simple linear functions are not sufficient to describe proficiency gains from training in a

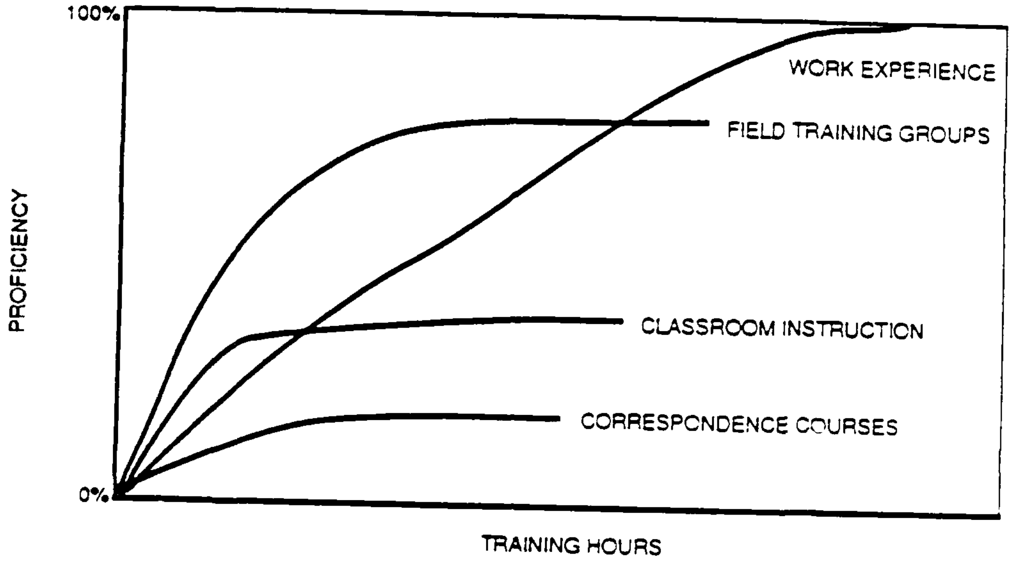

Figure 2. Hypothesized Relationship Between Hours of Training in a Setting and Proficiency Gain.

setting; rather, a curvilinear model more adequately describes this relationship.

A second rather consistent finding in the derivation of the allocation functions was that the most likely deviation from the polynomial regression model for all four AFSs involved training time judgments for self-study. Although the reason for this deviation from the hypothesized model for self-study times is not clear, two conjectures have been advanced. First, it is possible that the data are not sufficiently detailed or there is not enough information to detect the negatively accelerated curve. Given the generally lower reliability of self-study time judgments, more data would be required to detect a pattern. Second, it is also possible that the relationship between proficiency and self-study time is fundamentally different, either in nature or degree, than for the other training settings. For instance, since the lengths of training are relatively short and the proficiency gains rather small for self-study, it may be that a simple linear equation sufficiently describes this relationship for the range of training times considered.

3.3 Allocation Preferences

One model of allocation preference estimation might be called the "rational" model. Specifically, it holds that preference decreases linearly as the distance from the point of greatest preference increases. In the case of allocations to training settings, this model would specify that preference for an allocation to a setting should decrease as the time in that setting varies from the most preferred allocation. It would also predict that preference should be minimized at the time for that setting which still permits complete training to minimum standards but which is the most distant point. In other words, preference would be lowest at the least effective, though still adequate, allocation of training to a setting.

Before briefly describing how this model was implemented for TTM allocation preference estimation, the rational model should be compared to an alternative procedure--the empirical approach. Perhaps the most straightforward preference estimation procedure would be to collect preference information on a number of different allocations, and then empirically derive functions relating training time in a setting to preference. A requirement for the empirical approach is that a means of generating alternative allocation examples exist; thus, preference surveying would have to follow allocation surveying. Due to time limitations, this approach was not used. If the rational model is to be considered a viable approximation of preferences, however, it must be validated with actual preference ratings.

The preference measure developed for allocations of TTM training to settings is a four-point scale, and this index will be 4.0 only for the most preferred allocation. For any deviation from the most preferred allocation, the preference index will decrease, and the amount it decreases depends on the relative distance each setting's training time is from the most preferred level.

An example will illustrate this measurement scheme. Suppose, for simplicity, that the most preferred allocation for a TTM involved only two settings, the classroom and work experience, and we wish to estimate the preference for an alternative allocation also involving only the classroom and work experience settings. To estimate the relative change from the most preferred training level in a setting, the largest possible change from the most preferred level can be estimated from that level and either (a) the maximum effective time (training beyond this level in this setting has no appreciable effect) or (b) the minimum required time for a setting (at least this much training in this setting is required to reach minimum standards). The largest possible change is the larger of the differences between the most preferred allocation and the maximum effective time or between the most preferred allocation and the minimum required time. For this hypothetical example, the hours of training in the most preferred allocation, in an alternative allocation, the maximum effective time, and the minimum required time are as follows:

	Classroom	Self-Study	Field Trng	Work Exp
Most preferred allocation	20	0	0	45
Alternative allocation	30	0	0	40
Maximum effective time	30	10	15	100
Minimum required time	0	0	0	20

With these data, the largest possible deviation from the most preferred level of training in the classroom is 20 hours (the difference between the most preferred allocation and the minimum required time). The actual change for the alternative allocation was 10 hours, or a relative change of 0.50 ((20 - 10) / 20), one-half of the largest possible change. The largest possible change from the most preferred level for work experience is 55 hours (the difference between the most preferred and the maximum effective time). The actual change in the alternative was 5 hours, for a relative change of about 0.91 ((55 - 5) / 55). By summing the relative changes from the most preferred level of training for each training setting, a preference estimate of 3.41 is obtained: 1.0 for self-study (which remained unchanged), plus 1.0 for field training (which remained unchanged), plus 0.50 for classroom training, plus 0.91 for work experience.

All of the data points used in the calculation of this preference index were collected, or are derivable from, data collected with the allocation survey. The most preferred allocation and maximum training times were estimated by the survey respondents. It will be necessary, however, to "standardize" these times for the most preferred allocation, so that the times yield exactly 100% proficiency. Of course, any rating will contain some error, so that the rating of the most preferred allocation may yield slightly more or slightly less than full proficiency. Either case makes preference estimation problematic, since the index measures relative movement along the allocation curve. To resolve this problem, individual setting times can be converted to relative proportions of the total time. Then the total time can be adjusted, so that the sum of the proficiency gains from each setting is exactly 100%.

Finally, with estimates of the most preferred allocation that specify exactly 100% proficiency and maximum training times, the only other datapoint required for preference estimation is the minimum training time required in each setting. This time is easily derived from the maximum proficiencies for all other settings. If the maximum proficiencies from all other settings are summed, the minimum proficiency required from a setting is the difference between this sum and 100% (if the sum is less than 100%). If the sum is 100% or greater, there is no minimum proficiency requirement for that setting, or in other words, training to minimum standards can be achieved without use of that setting.

In sum, the procedures developed to obtain allocation judgments can be used effectively to estimate current and ideal training patterns and to describe relative deviation from the most preferred allocation. An additional important criterion for evaluating the practicality of these methods is the resource requirements for applying them. This issue is addressed in the section that follows.

3.4 Resource Requirements

The estimates of resource requirements for deriving TTM allocations are based on material costs and personnel salaries from Federal Service and Air Force salary schedules. They do not include charges for computer time, salaries for support personnel such as secretarial staff, or any travel expenses which might be required to convene groups of SMEs or to have TDS personnel meet with SMEs at remote bases.

In general, the process of deriving allocation functions for a specialty can be divided into three steps: (a) TTM allocation booklet development; (b) administration of the surveys; and (c) data analysis. Once TTMs were available for a specialty, the first step in allocation booklet development was to have SMEs group the TTMs according to similarity. These groupings of TTMs then became the basis for forming separate allocation booklets, which could be distributed to SMEs with experience in the tasks referenced in them. Also part of this step is assembling the booklets and duplicating sufficient copies (20 per booklet). The total cost of the TTM allocation booklet development step was estimated to be $1,750.45 to $2,080.67, depending on the diversity in the career field.

The second step was survey administration. All of the allocation booklets for a base were mailed to the Survey Control Officer, who handled distribution, collection, and return of the completed questionnaires. During booklet assembly and shipping, and in the subsequent weeks when completed surveys were being returned, an analyst would be responsible for overseeing booklet preparation and monitoring return rates. This responsibility would include, as required, answering questions concerning the survey from either the Survey Control Officer or the respondents. The cost of this step was estimated at $876.63

After all of the completed surveys were received, the data analysis step was begun. This step included data entry/keypunching, statistically analyzing the data, and interpreting and documenting the findings. The basic statistical analyses would include: (a) data verification, including range tests and internal consistency checks; (b) reliability estimation, including identification and removal of outliers; (c) generation of descriptive statistics on the current and most preferred allocations; and (d) derivation of allocation functions. The data verification step was handled by software designed for this purpose, but could also have been done with the interactive statistical package that was used for the reliability estimation, descriptive statistics, and multiple regression analysis. The total cost of this step was estimated at $2,373.73.

Thus, the total cost for applying the TTM allocation procedures discussed above ranges from $5,000.81 to $5,331.03, depending on the diversity in the career field. Again, these estimates do not include computer time charges, salaries for support personnel, or travel expenses (if any). It should also be noted that they are, at best, a rough approximation of what it would cost to apply the allocation data collection procedures to a new AFS. More definitive estimates are difficult to provide since previous work has blended data collection and analysis with R & D.

3.5 Conclusions

The R & D on the four specialties studied has identified a survey procedure that, with limited numbers of respondents, can yield adequately stable estimates of proficiency gains from hours of specified types of training. The allocation and preference functions derived from this survey procedure give the TDS maximum flexibility in considering different ways of dividing training among training settings, as well as identifying the limits of each type of training. Difficult issues such as proficiency measurement and the description of partial allocations of training to different training settings were generally resolved to the satisfaction of the many SMEs who have devoted their time to the development of these procedures. Nonetheless, the procedures should continue to be developed. In the short term, work could be directed at refining the allocation survey procedures. For example, AFS-specific examples of each type of training might facilitate accurate ratings. In the long term, alternatives or supplements to this basic survey methodology should be evaluated. The results of major research efforts to measure work performance, for example, might be integrated into the methods used to estimate training proficiency gains, to the improvement of the TDS. It is these directions for future research into enhanced TCS methodologies to which the final section of this report is devoted.

4.0 DIRECTIONS FOR FUTURE WORK

This section is divided into two parts, directions for future work in TTM construction and in TTM allocation. Additionally, each part progresses from relatively minor, but strongly recommended modifications of the basic data collection or analysis procedures to basic, long-term research into improved TCS methodologies. The former changes would result in immediate improvement in the quality of the TCS databases. The future research directions, on the other hand, have the potential to significantly or totally alter TCS methodologies.

4.1 TTM Construction

4.1.1 Sensitivity Analysis of the TDS to Changes in TTMs

Certainly one of the most important criteria by which the adequacy of the TTM construction methods can be evaluated is the degree to which TTMs fulfill their intended roles in the TDS. Chief among these roles are that they be appropriate for describing patterns of personnel utilization and training (both resident and field training, both current and alternative patterns), and that they encompass economies of training tasks together. The question of the specificity of TTMs can be addressed, consequently, by varying the breadth of the TTMs and evaluating the impact on Field Utilization Subsystem (FUS) and Resource/Cost Subsystem (RCS) products. This analysis of the sensitivity of TDS outputs to the specificity of TTMs would yield a great deal of information on how TTMs should be formed to meet the requirements of the operational system.

4.1.2 Nonhierarchical Clustering

Nonhierarchical clustering promises to provide some of the flexibility that hierarchical clustering lacks. Specifically, nonhierarchical clustering should permit tasks not classified by hierarchical techniques to be grouped with the most similar tasks. It also allows tasks to appear in more than one TTM. Nonhierarchical clustering should be fully evaluated as a TTM construction/refinement technique as soon as the procedure is fully operational.

4.1.3 Integration with Other Task Characteristics Research

Considerable research is being conducted which has implications for task clustering technology. Much of this work has been identified and described elsewhere (e.g., Mitchell, Sturdevant et al., 1987; Vaughan et al., 1985), and the TDS is being designed so that it can make productive use of these techniques. However, potentially valuable interfaces between the TDS and other systems will not occur unless research is conducted to assess the interdependencies and to integrate the technologies.

4.1.4 Task Characteristics Surveys

Task clustering based on task characteristics should be investigated. Research on clustering tasks using OS background characteristics was evaluated; unfortunately, these data are not gathered for this purpose and it is not possible to directly link OS background characteristics to tasks. To fully test the adequacy of task clustering based on equipment needed to accomplish the tasks, procedures/tactics used, or theories/facts that should be known, data which specifically link tasks with these characteristics should be gathered. The number of tasks and possible characteristics is large, however, making even simple tabulation of such linkages problematic. On the other hand, it might be possible for SMEs to indicate the important equipment, procedures, or knowledges for subsets of tasks. Additionally, information from senior personnel would not necessarily be required (except for tasks they perform), and so, the applicable pool of respondents would be substantially increased.

4.1.5 Construction of Knowledge TTMs

Occupational survey tasks are, by design, statements of observable actions incumbents perform on the job. Such behaviorally oriented statements are optimal for describing the structure of work. They may be less appropriate, however, for determining training requirements, since knowledge requirements for the tasks are not explicitly delineated. For example, knowledge of certain electronic principles may be required for performing a variety of different technical maintenance tasks, and OS task groupings may cut across such lines of distinction. Another example is in the area of contingency training, where occupational survey tasks which reflect day-to-day operations do not indicate the knowledges/skills necessary for emergency situations. Since different training settings may be more appropriate for imparting the knowledge component of task performance than the procedural component, allocation decisions for these different types of TTMs may vary.

Constructing TTMs composed of relevant knowledges (e.g., electronic principles, emergency situations) would seem to be an appropriate course of action. This approach would substantially increase the amount of data that would be required by the TDS, as catalogs of relevant knowledges, where they were not available, would have to be developed. Given such a list, a means of clustering would have to be developed; the procedures documented in Perrin et al. (1986) should serve as a useful starting point in this work. The clustering of knowledges would then have to be tied to the task modules; i.e., the knowledge clusters that are required for the performance of each TTM would have to be identified. Separate cost information would have to be developed for each of the knowledge groupings. With these data, personnel utilization patterns could describe required training for job performance in terms of both the knowledge and procedural requirements, and training decisions could take into account economies in both areas.

4.1.6 Tasks as the Units of Analysis

The key to making a task-based approach workable is to develop a complete task similarity matrix that reflects training economy and specifically, economy in training time. Skills and knowledge similarity would appear to serve such a function. Where there is considerable latitude to group tasks in various ways, such as in the basic resident course, blocks of instruction may represent relatively homogeneous clusters, and training time may be minimized as instruction on one task builds on what has already been learned about another. When practical or situational limits exist, such as the constraints job requirements place on what is trained in the work environment, the tasks that must be trained together may be a more heterogeneous group, and so, fewer training time economies can be realized. In other words, the time to train the group of tasks in the first case may be substantially less than the time to train each of them separately, whereas in the second case, the total time to train may approach the sum of the individual times.

The advantage of this approach is that the U & T pattern, current or alternative, would specify which tasks were grouped for each type of training, and the similarity of the tasks could then be used to specify the time economies of training the tasks together. Additionally, it is not clear that this approach would significantly change or increase the amount of information needed by the TDS. For example, tasks which have many skills and knowledges in common probably have similar training time requirements, so that such data could be collected for representative, rather than all tasks. Given the flexibility this approach would afford the TDS, these issues deserve closer study and evaluation.

4.2 TTM Allocation

4.2.1 TTM Grouping for Allocation Booklets

The method used to group TTMs into manageable units for allocation surveying was to have SMEs sort them according to similarity. This procedure is relatively expensive, especially if travel expenses are required, and proved to be ineffective in several cases. Perhaps the best example of the difficulty encountered using this approach was in AFS 423X1 for the Oxygen Systems Maintenance allocation booklet. TTM 31, Maintain Chemical Oxygen Generator, was placed in this booklet along with four other TTMs (numbers 17, 22, 26, and 28). The response rate on the latter four TTMs ranged from 7 to 9 raters; no nonzero responses were obtained on TTM 31 (only two respondents gave any ratings at all). Clearly, personnel that perform the other four TTMs are unlikely to perform TTM 31. This was not an isolated problem; similar problems were noted in the other AFSs.

The problem is that SMEs do not necessarily group TTMs according to co-performance, so that if airmen perform one of the TTMs in the booklet, they are also likely to be familiar with the others in that book. The result is that certain TTMs in the allocation booklets have very high response rates while others have low rates. Perhaps this problem could be reduced by directing the SMEs to group the TTMs according to co-performance; it is not clear, however, that this approach would be entirely successful. The research reviewed earlier on TTM construction indicates that SMEs groupings can be approximated by co-performance, and that there is variation among groups of SMEs as to how they cluster tasks given the same sorting instructions.

Three alternatives to the current method of grouping TTMs into allocation booklets are proposed. The first is to provide each allocation survey respondent with a TTM reference volume that lists all of the TTMs and the tasks in them. The respondent would then be asked to identify the 8 to 10 TTMs with which they were most familiar, and complete an allocation questionnaire for each of them. An approach similar to this is being used for the Training Time Questionnaire, a survey instrument used for data collection in the FUS, which is accompanied by a TTM reference volume.

The second alternative is to group the TTMs according to co-performance, using ASCII CODAP routines for co-performance clustering. If the task data were collapsed into TTM-level data, for example, by averaging over the tasks in the TTM, it would be possible to use CODAP programs to cluster TTMs. The TTM co-performance clusters identified from the cluster diagram would then form the allocation booklets. ASCII CODAP programs, discussed by Phalen, Staley, and Mitchell (1987), offer another option to clustering TTMs. They demonstrate a method of displaying a person by task matrix, with both the individuals and the tasks in TPATH (clustered) order. This product permits one to investigate the relationship between jobs (person clusters) and TTMs (task clusters). Such a product should be useful for refining task clusters to form TTMs and identifying the personnel performing the TTMs, so that allocation booklets can be mailed to appropriate individuals.

The final alternative is to customize or individualize the allocation booklet sent to each SME, based on the tasks the SME reported performing on the OS. For this approach to work, formation of TTMs and allocation surveying should follow the SME's completion and return of the OS as closely as possible. The allocation survey sent to each SME would contain only those TTMs the SME had indicated he or she had performed. This approach is perhaps optimal in targeting the most qualified airmen for allocation surveying. It does increase the expense incurred in preparing the surveys, since it is possible that no two surveys would be exactly the same; automating survey preparation could substantially reduce this expense, however.

4.2.2 Selecting the Survey Sample

In conjuction with modifying the method of grouping TTMs into allocation booklets, the method of selecting the SMEs to receive allocation booklets also needs to be refined. The method that has been used is to select those SMEs who reported performing the highest proportion of the tasks in a booklet. Unfortunately, this procedure omits the instructors who train, but do not actually perform the tasks. The result was that for all of the AFSs studied except 811XX, very few trainers were included in the survey (in AFS 811XX, trainers were included in a group administration of the survey).

Perhaps the simplest approach to this problem would be to compile a TTM reference volume, as discussed above, which would be sent to the appropriate technical training centers. Trainers would then select the TTMs for which they had responsibility, and complete allocation surveys for these TTMs. Again, this approach is being used for the Training Time Questionnaire.

4.2.3 Refine the Allocation Survey Instructions

Although it is almost always possible to improve the instructions to a relatively complex survey instrument, some problems have occurred with enough regularity to warrant changes in the allocation survey. First, rated training times of zero for all training settings has occurred rather frequently in all four AFSs studied. According to the survey's instructions, this rating should indicate that no training is required to reach minimum proficiency for this TTM. In practice, it may mean either that the SME was unfamiliar with the TTM or that the SME believed no one in the AFS currently performed the TTM. Improved sampling procedures, especially individualized allocation booklets, should make it less likely that an SME would, due to lack of familiarity with the TTM, indicate no training was required. An additional precaution against this confusion might be to add a warning concerning this situation, such as the following:

> Do NOT indicate no (zero) training times for all types of training, UNLESS NO TRAINING IS REQUIRED. If you have not been trained on the task module, please write DK (Don't Know) on the page, turn to the next page, and continue.

A second prevalent problem is the wide variation in training times reported, especially for work experience times. For example, one SME provided work experience time estimates in access of 20,000 hours to reach minimum proficiency on certain TTMs. Although it was possible to identify and remove the highly deviant estimates, it would be desirable to reduce their frequency by improving the instructions. Discussions with SMEs following group administrations of allocation surveys, as well as written feedback on the mail surveys, have indicated that the difficulty is one of calendar time compared to time-on-task estimates. Some SMEs appear to have provided total calendar time estimates rather than time-on-task estimates. The former is the total elapsed time before a TTM is mastered; the latter is the time spent actually working on or studying about the TTM. For instance, if a task in a TTM is encountered only about once a year and must be performed 3 times before minimum proficiency is reached, the calendar time estimate is 3 years. If, for the same task, 8 hours is needed to complete the task the first time, 6 the second, and 5 the third, the total time-on-task is 19 hours. A precaution against this problem might take the form of:

> Training times should indicate only the time spent learning about, studying about, or performing the tasks, NOT total calendar time.

A final problem noted in the allocation survey procedures was some confusion concerning the different types of training. Referents for some of the types of training are not always clear. This problem was perhaps most apparent in the AFS 811XX survey results. The clearest referent to field training groups is the FTD. In AFS 811XX, this type of training is not provided; consequently, SMEs in 811XX tended either to give nonzero field training times for all of the TTMs they rated or to none of them (presumably depending on whether they believed any of their training fell under the general title of field training).

The solution to this final problem is not as straightforward as the ones considered previously. One possible approach would be to list examples of specific training that were primarily of one type or another. Or, to be more complete, all training could be classified as primarily of the classroom, self-study, or field training types. Unfortunately, much training is a combination of two or three of these types, making classification of training difficult. It might be possible to indicate the parts of a course of study that were of each type; e.g., a particular course might consist of 1 week of lecture (classroom-type training) and 2 weeks of hands-on practice (field training). In addition to the difficulties of providing a meaningful classification of training into the three types of training, the classification might interfere with estimates of the most preferred allocation or maximum training times. Such interference was noted when actual training settings were used for allocation judgments rather than types of training. Nonetheless, this type of classification scheme holds great promise for improving the consistency and accuracy of allocation judgments and warrants further consideration.

4.2.4 Identifying and Handling Outliers

The work that was performed on identifying outliers, especially in AFS 811XX, indicated that an SME's judgments often were inconsistent with the group's ratings for only one or two of the types of training, rather than being inconsistent for all types. Part-whole correlations (the correlations between the SME's training time estimates for a particular TTM in a particular setting and the group average for the same rating) were often positive for some settings and negative for others. In other words, the SME would be consistent with the group's estimate for certain types of training (presumably the ones with which he or she was familiar), and inconsistent with others. How to handle this differential reliability is a question for further research.

One approach would be to exclude only those ratings which were highly deviant from the group average. For example, an SME's classroom time estimates which were highly inconsistent with the other SMEs' ratings for the same TTMs might be excluded from the sample. This SME's times for self-study, field training, and work experience would be retained. Unfortunately, for the derivation of the allocation curves, this approach has the same effect as removing all of the SME's ratings (since the case is dropped from multiple regression if any of the data are missing). An alternative is to replace the inconsistent data with the group average for that TTM and setting. Another approach would be to use a weighted average of the other settings' training times for that SME or of task characteristics for the tasks in the TTM (the weighted average being based on multiple regression). Finally, it is possible to develop regression equations from a correlation matrix that is based on partial data. Each of these approaches has its limitations and each has been studied as a general method for handling missing data in multiple regression. In the context of developing allocation curves, these methods of handling inconsistent data should be evaluated to identify a practical method of correcting for differential reliability.

4.2.5 Empirical Preference Curves

Functions which relate setting training times to managerial preferences should be developed and validated. Using the allocation functions that have been developed, a number of alternative, feasible allocations of training could be generated for each TTM. Then, preference ratings for each alternative could be obtained from appropriate Air Force training managers and the data statistically analyzed. Using this approach, the preference tradeoffs of allocating TTMs in different ways could be specifically modeled and represented in the TDS, much the same way that training time tradeoffs are currently represented.

4.2.6 Additional Validation Research

Additional work on validating the allocation curves should be performed. This research would necessarily focus on a limited number of TTMs, collecting detailed training information on them. These training data could then be compared to the survey results. Possible sources of bias in the survey results could be identified and perhaps remedied through this procedure.

4.2.7 Further Research on Time to Train

Section 2.0, Task Training Module Allocation, began with a discussion of some of the conceptual difficulties involved in measuring proficiency gain from training. Chief among them was developing a method of measuring proficiency, the subject of extensive research throughout the armed services. With a standardized, objective measure of performance on a task, proficiency gain could be measured as the change from before to after training of a particular type. The potential payoff for the TDS of performance assessment research in the Air Force is substantial, and efforts should be made to ensure that the results of performance assessment research are incorporated into the TDS, as appropriate.

Research on integrating and supplementing a systematic performance assessment program should be undertaken in the near future. Most of the work on performance measurement is at the task level or lower (the skills and knowledges underlying task performance), while the TDS operates at a task group level (TTMs). Additionally, performance measurement programs are not generally concerned with time to train, a key statistic for the TDS. Methods of estimating training times at the skill/knowledge level and then aggregating those estimates to the TTM level should be developed and evaluated. Although the potential benefits to the TDS of a systematic performance program are substantial, this payoff will not be realized without further R & D of performance assessment technologies.

Quite apart from the performance assessment research, further research on time to train TTMs in different training settings could be of considerable value to the TDS. For example, group consensus judgments could be compared to the survey averages which are currently being used. Presumably, group judgments would be less prone to the type of differential reliability observed in the survey results, since a group is more likely to have at least one person familiar witn each of the training settings.

4.3 Priorities of Future Research

Some hard choices must be made among these various future R & D alternatives since it is unlikely that all the alternatives outlined could be fully funded or accomplished in a reasonable timeframe. Thus, some prioritization must be made among the various alternatives.

It is quite possible that the on-going R & D of the other TDS subsystems may provide some answers relevant to these TCS research issues, or at least provide data useful in prioritizing among the various directions which future R & D might take. In addition, some of the issues are being addressed in the continuation phase of the present contract (Ammendment No. 3). For the purposes of this report, it is sufficient to conclude that the present system developed for the prototype TDS works reasonably well even though additional R & D is desirable to make the operation of the TCS more efficient and thus more cost-effective.

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ACRONYMS AND ABBREVIATIONS

AF	Air Force
AFB	Air Force Base
AFS	Air Force Specialty
ATC	Air Training Command
CDC	Career Development Course
CODAP	Comprehensive Occupational Data Analysis Programs
DIAGRM	Program in CODAP for displaying hierarchical clustering results
FTD	Field Training Detachment
FUS	Field Utilization Subsystem
GROUP	Program in CODAP for clustering cases or tasks
IOS	Integration and Optimization Subsystem
KPATH	Clustered sequence (or path) for cases from GROUP
OJT	On-the-Job Training
OS	Occupational Survey
OVRLAP	CODAP program to compute a similarity matrix
PMI	Preventive Maintenance Inspection
PRTVAR	Print Variable program to display variable values
RCS	Resource/Cost Subsystem
SME	Subject-Matter Expert
SOW	Statement of Work
STS	Specialty Training Standard
TCS	Task Characteristics Subsystem
TDS	Training Decisions System
TPATH	Task clustering sequence from GROUP with transposed case data
TTM	Task Training Module
U&T	Utilization and Training
XPOSE	Program in CODAP for transposing case data files

APPENDIX A

GUIDELINES FOR CONSTRUCTING TASK TRAINING MODULES

Guidelines for Constructing Task Training Modules (TTMs)

This Appendix provides general guidelines for the development of Task Training Modules (TTMs) for use in the Training Decisions System (TDS). These recommended procedures are based on the research and development (R&D) of the Task Characteristics Subsystem (TCS) in the prototype TDS project under AFHRL Contract Number F33615-83-C-0028. This TCS R&D is described in the main body of this report as well as earlier TCS-related contract deliverables (see Perrin, Vaughan et al., 1986; Perrin, Mitchell, & Knight, 1986). Specific CODAP runstreams required for the initial phase of this procedure are detailed in the Task Characteristics Subsystem Software report, delivered to AFHRL in June 1987.

Overview - The recommended TTM development procedure is a three-phased process:

1. Statistical clustering of the Occupational Survey (OS) tasks for the specialty using co-performance as the similarity measure;

2. Interpreting the co-performance cluster diagram, identifying initial TTMs based on patterns of between and within group similarity; and,

3. Having subject-matter experts (SMEs) of the specialty name the task groupings, place tasks that could not be grouped based on the clustering results, and refine the initial clusters to form final TTMs.

Guidelines for constructing TTMs are organized around these three steps, and details are provided on how each step should be conducted. Such guidelines are based on experience with the four specialties studied in the prototype TDS project, and are subject to possible modification as the system is used with additional Air Force specialties. In addition, as more of the new ASCII CODAP tools for task clustering analysis are operationally tested and become available (Phalen et al., 1987), additional guidelines may be needed.

PHASE 1. - STATISTICAL CLUSTERING

TTM construction begins with the U.S. Air Force Occupational Measurement Center (USAFOMC) occupational survey (OS) tasks for the specialty under study. The tasks of the AFS are clustered statistically using co-performance as the similarity measure to generate tentative TTMs. This process involves using ASCII CODAP (developed for AFHRL by the MAXIMA Corporation under Air Force Contract F41800-87- M8657) files and programs in a different way (see Figure A-1).

A. CONVERT (if necessary) - The process begins with existing CODAP files for the specialty which are available at AFHRL and can be loaded to the AFHRL Sperry-Univac computer. If such AFS CODAP files are recent (1987 or later), they are probably in ASCII CODAP format and can be processed directly. For older USAFOMC studies, the AFS CODAP file probably requires conversion to the newer ASCII CODAP format to create the

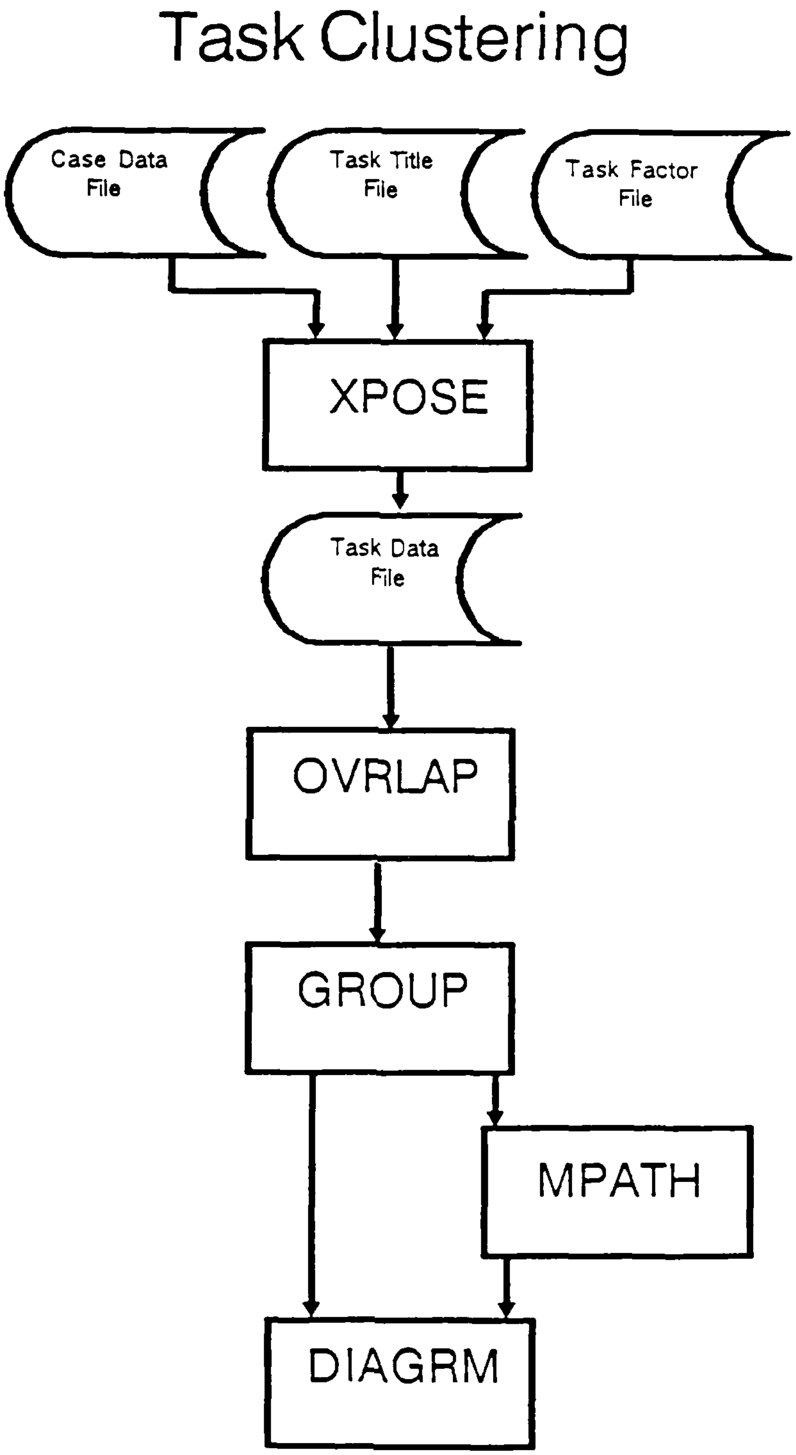

Figure A-1. Statistical Clustering of Tasks to Develop Task Training Modules. (Flow diagram adapted from the ASCII CODAP Training Package developed by the MAXIMA Corporation under AF Contract F41800-87-M8657).

study file. For task clustering, the study file must include both the Case Data File and Task Title File. (In some studies, if you wish to display any task factor data, the Task Factor File should also be included.)

[The conversion process is documented in ASCII CODAP program descriptions under the title CONVERT. To review this program description (or descriptions of subsequent programs) on the AFHRL Sperry-Univac, log-on with a user ID, then enter:

@Z*ZA.doc ---> MENU

Select the ASCII CODAP option ---> list doc names

Identify CONVERT program number (#)

Enter V # to view or P # to print a copy]

B. TRANSPOSE - Given an ASCII CODAP Case Data File, the first step in producing a task co-performance cluster diagram is to transpose the case data using an ASCII CODAP program titled XPOSE. Use the "raw task responses" option in transposing the file. This routine changes the file from a case-oriented to a task-oriented form. Thus, rather than task performance data for each respondent, the resulting new file is composed of respondent performance data for each task. Once the OS Case Data File is transposed, clustering is performed using the normal CODAP clustering sequence of OVRLAP, GROUP, and DIAGRM.

C. OVRLAP - This program computes a similarity measure between each pair of tasks contained in the transposed Case Data File. Select the co-performance option in executing this program. The resulting similarity matrix computed by OVRLAP includes the degree to which all pairs (or groups) of tasks are jointly performed (average co-performance) for all respondents (cases).

[OVRLAP will normally cluster a maximum of 7,000 cases and 3,000 tasks. With a transposed case data set, this means there is a maximum of 3,000 cases which can be compared at one time. For larger Occupational Survey Report (OSR) studies, with a sample size greater than 3,000, a random sampling of not more than 3,000 cases should be used. For very large or important studies, multiple random samples could be generated and resulting groupings compared to ensure the generality of results.]

D. GROUP - This program reads the similarity matrix produced by OVRLAP and organizes the most similar groups into hierarchical clusters iteratively until all tasks have been included. Default options are used so that the most similiar pair (or group) is selected to merge and their values averaged to generate values for the new group. The Output Cluster File records the collapse of tasks into groups from single pairs to their merger in the final total sample stage (GRP001). Another product of this program is a listing of tasks in cluster sequence.

[The cluster sequence file, formerly known as KPATH, is an important product needed for the interpretation of the groups and clusters. For task data, this sequence listing is sometimes referred to as a TPATH list or order (as opposed to Case Data File or KPATH). Such a TPATH listing is produced by requesting a PRTVAR which includes the task statements and task identifiers (task number and duty area) for use during analysis. ASCII CODAP also includes an MPATH program option which gives the user the ability to reorder the Cluster sequence based on certain specified variables, without changing the results of the clustering process. Thus, MPATH changes the diagram display by placing higher weighted groups or clusters to the left, giving an ordered sequence. This option is not used in present TDS Task Clustering projects, but may become important in future Task Clustering developments (for example, possible nonhierarchical reclustering refinement).]

E. DIAGRM - This program prints a picture which shows how the groups in the clustering merged together to form a single composite stage. The resulting report is a multipanel tree structure which displays how all the tasks of the specialty relate to each other in terms of average co-performance. This product is the starting point for analysis or interpretation of potential task groupings.

PHASE 2. ANALYSIS OF TASK CLUSTERS

Once a task cluster diagram has been produced, an analyst is needed to identify potentially meaningful groups of tasks as potential TTMs. The analyst needs to be familiar with CODAP hierarchical diagrams and must be able to assess the data such diagrams provide.

Since task cluster diagrams are new and their information somewhat different from normal case cluster diagrams, some very basic details will be reviewed. Figure A-2 illustrates an element of a hypothetical task clustering diagram to serve as the basis for this review.

Stage Number - This is the identification number of the Group from the GROUP program. It is used to track the group through various programs and displays. In a typical OS, such groups would be composed of people (cases); in this situation, the groups are sets of tasks.

Number of Tasks - Literally, the number of tasks in the group.

TPATH Sequence - The range of sequence numbers identifying which tasks are involved in this group. Cross-reference to the TPATH listing (PRTVAR).

Overlap Between - The data in the lower left-hand corner of the diagram element is an index of the similarity of the two groups of tasks merging to form this new group. It represents the average of their co-performance values.

Overlap Within - Once the new group has been formed, the average co-performance among the tasks is recomputed to assess internal homogeneity of the group; this value is displayed in the lower right corner of the diagram element.

```
            Grouping       Number of Tasks
            Stage Number     in the Group
                  \             /
                   \           /

                     0540 0004
                     0624-0627 ---------- TPATH Sequence Numbers
                     90.8 95.2

                      /       \
                     /         \
                    /           \
   Average Co-performance    Average Co-performance
   Overlap Between the       Overlap Within This Group
   Two Groups Merging
   to Form This Group
```

Figure A-2. Data in a Typical Task Clustering Diagram Element.

These types of information are provided for each stage of the hierarchical clustering process. Since a display of all groups would be extremely massive, normally only a portion of the data is displayed in the diagram. Typically, OSR diagrams are limited to "starter" groups of 5 or more, or with overlap values less than some specified value. For Task Cluster diagrams, starter group size should be set lower (at 2 or 3) to permit examination of pairs or triads of tasks.

To facilitate further discussion of identifying meaningful groups of tasks, a portion of the AFS 328X4 task clustering diagram is shown as Figure A-3. Figure A-4 displays the relevant portion of a PRTVAR for AFS 328X4 in cluster sequence (TPATH) order of tasks.

Using these two ASCII CODAP products, the Task Cluster Diagram and the TPATH Sequence Listing, an analyst must identify potentially meaningful groups of tasks to be tentative TIMs. This is accomplished by systematic examination of portions of both documents for patterns of variance.

A. Diagram - A visual inspection of the diagram (Figure A-3) indicates generally high Between and Within overlap values. This appears to be typical of those parts of a task list involving specialized technical areas (specific equipment maintenance, procedures), with much lower overlap values for managerial and supervisory tasks. Clearly, however, the usual rules-of-thumb for OS (case) diagrams, such as the 35/50 rule, do not apply. Application of such a rule would result in extremely large TIMs of 75 to 150 tasks going across several duty areas and involving several equipment systems. Rather, the analyst must examine the relative overlap values in the vertical linkages of the diagram, paying particular attention to groups where there is substantial drop-off in overlap as groups merge.

```
0742 0006   0736 0009   0586 0006   0621 0007   0669 0008   0646 0011
0714-0719   0724-0732   0738-0743   0744-0750   0752-0759   0760-0770
98.9 99.4   98.5 99.0   92.9 94.6   93.0 96.0   95.4 96.7   94.0 96.1
    |           |           |           |           |           |
0737 0007   0722 0010       |       0563 0008   0612 0019       |
0714-0720   0724-0733       |       0744-0751   0752-0770 -------
98.6 99.2   97.7 98.9       |       89.6 94.6   92.5 94.4
    |           |           |           |           |
0731 0008   0709 0011   0527 0014       |       0565 0020
0713-0720   0724-0734   0738-0751--------       0752-0771
98.3 99.0   97.0 98.5   87.7 91.2               89.7 94.0
    |           |           |                       |
0728 0009   0704 0012       |                   0555 0021
0713-0721   0724-0735       |                   0752-0772
98.0 98.8   96.9 98.3       |                   89.2 93.6
    |           |           |                       |
0724 0010       |           |                   0536 0023
0713-0722       |           |                   0752-0774
97.7 98.6       |           |                   88.3 92.8
    |           |           |                       |
0702 0011       |       0747 0037                   |
0712-0722       |       0738-0774 -------------------
96.9 98.4       |       84.6 88.7
    |           |           |
0695 0012       |           |
0712-0723       |           |
96.7 98.1       |           |
    |           |           |
0691 0024       |           |
0712-0735 -------           |
96.4 97.3                   |
    |                       |
0529 0026                   |
0712-0737                   |
87.7 96.4                   |
    |                       |
0268 0027                   |
0711-0737                   |
67.8 94.4                   |
    |                       |
0219 0064                   |
0711-0774 -------------------
63.6 77.5
    |
    |
```

Figure A-3. Example Task Cluster Diagram (AFS 328X4).

Sequence No. or TPATH	Duty	Task	Task Title
.			
.			
.			
0708	W	651	Inspect Clean Air Stations
0709	W	695	Isolate Malfunctions to Clean Air Station Components
0710	W	758	Repair Clean Air Stations
0711	J	322	Remove or Replace Heading Couplers
0712	T	546	Isolate Malfunctions to MADAR Computers
0713	T	547	Isolate Malfunctions to MADAR Control & Sequence Units
0714	T	548	Isolate Malfunctions to MADAR Data Retrieval Units
.			
.			
.			
0727	T	567	Remove or Replace MADAR SAR
0728	T	560	Remove or Replace MADAR SCU
0729	T	563	Remove or Replace MADAR MMUX
0730	T	565	Remove or Replace MADAR POU
0731	T	562	Remove or Replace MADAR MDR
0732	T	568	Remove or Replace MADAR SCA Units, such as Temperature, Pressure, or Vibration
0733	T	570	Reprogram MADAR Computers
0734	T	569	Remove or Replace MADAR SCM
0735	T	566	Remove or Replace MADAR Recording Tapes
0736	T	557	Operate MADAR for System Interface Check-outs
0737	T	571	Teach MADAR Troubleshooting Techniques
0738	U	572	Adjust MADAR CMA
0739	U	576	Adjust MADAR MMUX
0740	U	573	Adjust MADAR SCU
0741	U	577	Adjust MADAR ODRU
0742	U	575	Adjust MADAR MDR
0743	U	574	Adjust MADAR DRU
0744	U	578	Align MADAR CMA
0745	U	579	Align MADAR CSU
0746	U	581	Align MADAR MDR
.			
.			
.			
0771	U	608	Program MADAR Computers
0772	U	596	Bench Check MADAR SCM
0773	U	606	Isolate Malfunctions to SCA SRU
0774	U	607	Isolate Malfunctions to SCM SRU
0775	K	347	Align Heading Couplers
0776	K	358	Bench Check Heading Couplers
0777	K	372	Isolate Malfunctions to Heading Coupler SRU
0778	K	385	Remove or Replace Heading Coupler SRU

Figure A-4. Example of TPATH Sequence Task Listing (Extracted from "PRTVAR for AFS 328X4 Tasks in KPATH Order, Transpose of Raw Data").

EXAMPLE: For the AFS 328X4 diagram, good candidate TTMs would be (reading up from the bottom of the figure) groups 0219, 0691, 0747, and the pairs of groups merging to form the latter two groups (0695 & 0704; 0527 & 0536). Note that the Between and Within overlap for GRP 0691 (96.4 & 97.3) drops substantially when it merges with GRP 0747 to form GRP 0219 (down to 63.6 and 77.5), where in the intervening steps (0268 & 0529), the reduction is more gradual. We need to examine the tasks involved (TPATH 735, 736, 737, 738, etc.) to see if we can see how these groups are different (and how they are the same).

B. Cluster Sequence (TPATH) - An analyst needs to also examine the listing of tasks in clustered (TPATH) sequence (see example in Figure A-4) again looking for patterns of variance. In this case, one should examine Duty and Task identifiers for strings or patterns of related tasks, as well as the content of the task titles or statements themselves for common content (equipment, procedures, action verbs, etc.).

EXAMPLE: A look at the AFS 328X4 PRTVAR indicates that all the tasks in this part of the diagram (TPATH 0712 - 0774) involve MADAR maintenance (OSR Duties T and U). There is a break after TPATH 0774 (where GRP 0219 ends) with a switch to Duty K; these Duty K tasks involve Heading Couplers, which is quite a different system. Even within TPATH sequence 0712 - 0774, there is a distinct break between tasks 0737 (which is a Duty T task) and 0738 (which is Duty U). The Duty T tasks are Remove and Replace tasks whereas the Duty U tasks involve Adjusting, Aligning, and Bench Checking MADAR components. This appears a meaningful difference (Overlap drop-off, Duty and content difference). This difference seems to be associated with flightline (on-aircraft) maintenance (the remove and replace tasks) and shop (off-aircraft) maintenance (adjust, align, bench check, etc.). This difference is striking in this example, but in other parts of the diagram may be mixed to a greater degree. The only difference in this sequence and GRP 0219 on the diagram is Task 0711 (J 322 Remove or Replace Heading Couplers); it does not fit into the MADAR repair group.

C. Isolate Tasks - Once the potential TTMs are identified, there still remain some tasks which are not included, or which appear inappropriate; some may be related to the overall area, but enter the clustering lower down on the diagram after the major clusters have formed. These tasks are termed "Isolates" since they are not part of the identified groups; decisions must be made as to how to handle such tasks. Are they a group or should they be considered isolated individual tasks? Should they be forced into one of the major groupings and, if so, which one? Are they related in content to this area of the diagram, or to some other region? If a quick look at such tasks indicates they have some content relationship to this area, they should be dealt with here; if not, defer their consideration until all major areas of the diagram have been evaluated.

EXAMPLE: Task 0711 (J 322 Remove or Replace Heading Couplers) is the only J task in the example TPATH listing--it simply does not fit. In content, it appears more like the Duty K tasks (TPATH sequence 775 - 778) at the end of the list; those tasks also involve Heading Couplers. Typically, an analyst will not have sufficient knowledge of the technical area involved to determine if Task 711 should be arbitrarily moved to be a part of a Heading Coupler TTM, or should be considered a separate TTM in its own right. In addition, two of the tasks at the interface of the diagram groups (TPATH 736 and 737) also are qualitatively different (Operate and Teach rather than maintain). Note that on the Diagram (Figure A-3) these two tasks enter below GRP 691; that is, they are outside of the two major MADAR maintenance TTMs. These tasks may be performed by everyone involved with MADAR or by only a few individuals. For resolving this kind of evaluation problem, the judgment of SMEs is of critical importance.

In general, an analyst can select a reasonable set of tentative TTMs using the procedures outlined above. In some cases (as in our MADAR example), the common theme of the tasks involved clearly suggests the generic principle for the task groupings (such as On-Aircraft MADAR Maintenance versus MADAR Shop Maintenance). There remain, however, some isolated tasks, or sets of tasks, which are ambiguous in their relationship to other task groups. Typically, at the end of the TPATH sequence list, there will also be a few tasks which do not appear to fit anywhere; they may be individual TTMs in their own right, or may in fact be related to some identified group in some way not obvious to the analyst.

PHASE 3. - SUBJECT-MATTER EXPERT REVIEW

A review of the tentative TTMs (selected by an analyst) by a representative group of technical experts who are thoroughly familiar with the Air Force specialty involved serves a number of purposes. These SMEs can quickly validate the groupings selected by the analyst. Secondly, SMEs are more technically qualified to decide a proper name for the TTMs; their generic term for each TTM should communicate the basic content of each TTM to anyone in the specialty. Thirdly, SMEs can quickly resolve the questions an analyst has about how Isolates fit into the work of the specialty and to which TTM (or TTMs) such Isolates relate. Finally, for those anomalous tasks which do not fit anywhere, SMEs can make realistic judgments as to whether such tasks should be treated as individual TTMs, or merely be left as a "Miscellaneous" TTM.

Ideally, a representative panel of SMEs should be convened to conduct this TTM validation. In practice, this may be impossible or impractical due to the wide geographic distribution of specialized Air Force jobs. In any case, the TTM review must be done in a systematic way both to ensure that good judgments are made and to minimize the amount of time SMEs must be diverted from their operational duties.

A. Construction of TTM Review Booklet - The analyst develops a special booklet of TTMs for use in SME reviews. The ASCII CODAP program called

MODULES can be used to construct this booklet; the analyst maps the tasks into numbered modules (without narrative titles, for the present). The final module should include all tasks not grouped, to ensure that all tasks are considered.

[Since manipulation of tasks out of their normal Duty and Task Number sequence can be complex, it is good to have the program count the number of task entries. This total should equal the number of tasks in the USAF Job Inventory; if not, then some task has been omitted or included more than once.]

The analyst then requests a printout in module order. Task identifiers (Duty, Task No., TPATH No.) should be omitted to focus the SME review on task content. Have each TTM printed on a separate page; again, this format tends to focus SME review on the commonality of the tasks on a page and thus expedites their review and validation process. The printout should have a title page which includes the AFSC involved and notes that these are "TENTATIVE Task Training Modules."

B. Selecting Representative SMEs - The diversity of jobs and tasks within an Air Force specialty dictates the number and qualifications of SMEs needed for TTM validation. For a typical specialty where most tasks are performed by most individuals, a group of three or four SMEs, preferably TSgt or MSgts who have been assigned to a number of bases, would suffice. For more complex specialties, with very diverse and specialized jobs, the number of SMEs required will be greater. The OSR provides general information about the diversity of jobs and the MAJCOM distribution of personnel in the specialty. It does not typically include information as to specific bases where identified jobs are performed.

[The Background Data PRTVAR for the OSR study should be retrieved from tape storage at AFHRL and printed, to provide a good basis for SME sampling. Include KPATH sequence numbers in the product to be printed, along with name, AFS, base, etc.; the KPATH numbers are needed to link individuals to specific job types, and thus, indirectly, to identify where the groups of tasks are performed.]

C. Group Interviewing or Surveying - If sufficient representative SMEs can be identified in the local area, a group meeting should be convened to validate and review the TTMs. If this is not possible, because of operational commitments or lack of travel funds, then a mail survey may be the only option.

In either case, the SMEs should be asked to first read through the TTM Review booklet completely to orient themselves to the task statements and tentative groupings. They should be instructed to go through the booklet a second time and name each TTM and closely examine the tasks of each TTM to ensure that all tasks are appropriate for this grouping. They should also be instructed to carefully examine the final page, the ungrouped tasks, and decide whether these tasks should be placed with some TTM, made a separate TTM, or left in a Misc. category. If the review is conducted as a group session, SMEs should compare their decisions and arrive at a consensus judgment for each of the issues. For mailed surveys, the analyst must consolidate responses and make some arbitrary decisions on the most appropriate titles and possible changes to TTMs or the ungrouped tasks. Such changes could be discussed by phone with survey participants.

D. Preparing Final TTM Listing - A final step in the TTM Construction process is to enter the names or titles selected for TTMs into the TTM Module File and make the other changes decided by the SMEs (or, in the case of mail review, by the analyst), such as any shifting of tasks or creation of new TTMs. By using the MODULES programs for constructing the TTM Review booklets, the identity of the TTMs and their task content are automatically part of the ASCII CODAP AFS study file. The revised file is then available for use in other TDS activities and serves as the foundation for the TDS study of the Air Force specialty involved.

APPENDIX B

SAMPLE SURVEY FORMAT

Sample of the first of two TTM Allocation Survey formats field-tested in AFS 811XX at Lackland AFB, TX (see section 3.1 for a description of this field test). Included are the instructions, one of the task modules evaluated, and the response sheet used to record allocation decisions. Respondents used a "percent of full training" measure to describe different allocations.

GENERAL INSTRUCTIONS

Your assistance in completing this survey is very important to the Air Force. AF training may occur in several different settings including resident technical schools (CLASS), Career Development Courses (CDC), Educational Subject Block Indices (ESBI), and on-the-job training(OJT). One important decision in building effective training programs is how to divide training among these training settings (how much to teach where).

This questionnaire is designed to determine the following for a group of occupational tasks:

1) the LEVEL OF TRAINING that is, should, and can be provided in each of the training settings; and
2) the TIME it will take to train the tasks to these levels in each setting.

KEY CONCEPTS

Training Settings

CLASS: All resident technical training including basic and advanced courses relevant to the tasks (tech schools). All Professional Military Education (PME) that occurs in the classroom should be included in this category.

CDC: All Career Development Courses relevant to the tasks. All management training by correspondence should be included in this category.

ESBI: All training provided through Educational Subject Block Indices relevant to the tasks.

OJT: All activities of the trainee and the trainer relevant to learning the tasks. Relevant trainee activities may include practice, studying training or technical manuals, receiving instruction, or observing others demonstrating the tasks. Relevant trainer activities may include verifying, monitoring, and observing the trainee's work and providing instruction, direction, and feedback on that performance.

Training Time

The number of hours required, on average, for a trainee to achieve a given level of training in a setting. Separate estimates of trainer time will also be needed for OJT.

Level of Training

The level of training in a setting can go from no training to full training. For this questionnaire, full training means "able to perform the tasks to minimum acceptable standards without direct supervision". It does NOT mean expert or highly skilled performance.

To describe the level of training for each setting, indicate the percent of full training provided. 0% means no training is to be provided in a setting. 100% means that all training necessary for an airman to satisfactorily perform the tasks without supervision is to be provided in that setting.

Current Training Level and Training Time

The level of training provided in each setting under the current training system and the time it takes to provide this training (the way things are now). Note that the percents of full training must add to 100%.

EXAMPLE:

Training Time (in hours)

Level of Training
(percent of full training)

Current Training Level
(the way things are now)

CLASS: 30% 10
ESBI: 20% 6
CDC: 0% -
OJT: 50% 20 (trainee)
25 (trainer)
TOTAL: 100%

Ideal Training Level and Training Time

Level of training that should be provided to make the best use of a training setting, DISREGARDING costs and number and location of airmen performing the tasks (the way things should be). Again, the percents must add to 100%.

EXAMPLE:

Ideal Training Level
(the way things should be)

CLASS: 30% 10
ESBI: 30% 8
CDC: 0% -
OJT: 40% 15 (trainee)
20 (trainer)
TOTAL: 100%

Minimum Entering Background

Minimum level of training (if any) an airman should have before beginning training in a setting, so that this training may be effective. Note that the minimum training level must be 0% for at least one setting; these are settings which require no previous training. Percents need not add to 100% and no training times are needed.

EXAMPLE:

Minimum Entering Background CLASS: 0%
ESBI: 0%
CDC: 10%
OJT: 20%

Maximum Training Level and Training Time

Maximum level of training that can be reached effectively in a setting. Percents need not add to 100%. Training times indicate the time required to reach the maximum level if the airman started with the minimum entering background.

EXAMPLE

Maximum Training Level CLASS: 50% 22
ESBI: 60% 25
CDC: 40% 20
OJT: 100% 35 (trainee)
40 (trainer)

INSTRUCTIONS

On the next page, you will find some tasks that have been grouped together because they are coperformed; that is, if an airman does one of the tasks, he or she probably does one or more of the others. Read through the list of tasks. Then, using the percent of full training provided, describe the current training level, the ideal training level, the minimum entering background, and the maximum training level for each training setting. Also indicate the training time needed to achieve these levels in each setting.

TASK GROUP NO. 1: Processing Incident Investigation Forms

Make entries on AF Forms 1168/1170 (Statement of Suspect)

Make entries on AF Forms 1169/1170 (Statement of Witness)

Make entries on AF Forms 1176 (Authority to Search and Seize)

Make entries on AF Forms 1364 (Consent for Search and Seizure)

Make entries on AF Forms 1668 (Field Interview)

Make entries on AF Forms 52 (Evidence Tag)

Concerning the above tasks, I am:
(mark one box)

☐	☐	☐	☐
not at all familiar with them	slightly familiar with them	moderately familiar with them	very familiar with them

If you marked the first box, please skip the next page and continue with the next group of tasks.

Training Time (in hours)

Level of Performance
(use scale on facing page)

Performance Level Prior to Training ______

Current Training Level
(the way things are now)

CLASS:______ ______
ESBI:______ ______
CDC:______ ______
OJT:______ ______(trainee)
______(trainer)

Ideal Training Level
(the way things should be)

CLASS:______ ______
ESBI:______ ______
CDC:______ ______
OJT:______ ______(trainee)
______(trainer)

Minimum Entering Background

CLASS:______
ESBI:______
CDC:______
OJT:______

Maximum Training Level

CLASS:______ ______
ESBI:______ ______
CDC:______ ______
OJT:______ ______(trainee)
______(trainer)

Sample of the second of two TTM Allocation Survey formats field-tested in AFS 811XX at Lackland AFB, TX (see section 3.1 for a description of this field test). Included are the instructions, one of the task modules evaluated, and the response sheet used to record allocation decisions. Respondents used a seven-point rating scale to describe different allocations.

GENERAL INSTRUCTIONS

Your assistance in completing this survey is very important to the Air Force. AF training may occur in several different settings including resident technical schools (CLASS), Career Development Courses (CDC), Educational Subject Block Indices (ESBI), and on-the-job training(OJT). One important decision in building effective training programs is how to divide training among these training settings (how much to teach where).

This questionnaire is designed to determine the following for a group of occupational tasks:

1) the LEVEL OF PERFORMANCE that is, should, and can be attained in each of the training settings; and
2) the TIME it will take to train the tasks to these levels in each setting.

KEY CONCEPTS

Training Settings

CLASS: All resident technical training including basic and advanced courses relevant to the tasks (tech schools). All Professional Military Education (PME) that occurs in the classroom should be included in this category.

CDC: All Career Development Courses relevant to the tasks. All management training by correspondence should be included in this category.

ESBI: All training provided through Educational Subject Block Indices relevant to the tasks.

OJT: All activities of the trainee and the trainer relevant to learning the tasks. Relevant trainee activities may include practice, studying training or technical manuals, receiving instruction, or observing others demonstrating the tasks. Relevant trainer activities may include verifying, monitoring, and observing the trainee's work and providing instruction, direction, and feedback on that performance.

Training Time

The number of hours required, on average, for a trainee to achieve a given level of training in a setting. Separate estimates of trainer time will also be needed for OJT.

Level of Performance

To indicate the level of performance attained in a setting, please use the following scale.

The trainee can perform:
- 0 = no aspects of the tasks independently; requires constant direction
- 1 = very few aspects of the tasks independently; requires nearly constant direction
- 2 = some aspects of the tasks independently; requires substantial direction
- 3 = many aspects of the tasks independently; requires some direction
- 4 = most aspects of the tasks independently; requires little direction
- 5 = nearly all aspects of the tasks independently; requires very little direction
- 6 = all aspects of the tasks to minimum standards without direct supervision.

Performance Level Prior to Training

The performance level of airmen prior to any AF training. For simple tasks, this will be high; for difficult tasks, this will be low. Note that no training time estimate is needed.

EXAMPLE:

Training Time (in hours)

Level of Training
(using the rating scale)

Performance Level Prior to Training: 1

Current Training Level and Training Time

The level of performance attained in each setting under the current training system and the time it takes to provide this training (the way things are now): Note that one setting must receive a rating of 6, indicating that minimum acceptable performance has been attained from the training program.

Current Training Level
(the way things are now)

CLASS: 2 10
ESBI: 3 6
CDC: - -
OJT: 6 20 (trainee)
25 (trainer)

Ideal Training Level and Training Time

Level of performance that should be sought to make the best use of a training setting, DISREGARDING costs and number and location of airmen performing the tasks (the way things should be). Again, one setting must receive a rating of 6.

EXAMPLE:

Ideal Training Level
(the way things should be)

CLASS: 2 10
ESBI: 4 8
CDC: - -
OJT: 6 15 (trainee)
20 (trainer)

Minimum Entering Background

Minimum level of performance an airman should have before beginning training in a setting, so that this training may be effective. No training times are needed.

EXAMPLE:

Minimum Entering Background

CLASS: 1
ESBI: 1
CDC: 2
OJT: 3

Maximum Training Level and Training Time

Maximum level of performance that can be reached effectively in a setting. Training times indicate the time required to reach the maximum level if the airman started with the minimum entering background.

EXAMPLE

Maximum Training Level	CLASS:	5	22	
	ESBI:	5	25	
	CDC:	4	20	
	OJT:	6	35	(trainee)
			40	(trainer)

INSTRUCTIONS

On the next page, you will find some tasks that have been grouped together because they are coperformed; that is, if an airman does one of the tasks, he or she probably does one or more of the others. Read through the list of tasks. Then, using the rating scale for the level of performance, describe the current training level, the ideal training level, the minimum entering background, and the maximum training level for each training setting. Also indicate the training time needed to achieve these levels in each setting.

TASK GROUP NO. 1: Processing Incident Investigation Forms

Make entries on AF Forms 1168/1170 (Statement of Suspect)

Make entries on AF Forms 1169/1170 (Statement of Witness)

Make entries on AF Forms 1176 (Authority to Search and Seize)

Make entries on AF Forms 1364 (Consent for Search and Seizure)

Make entries on AF Forms 1668 (Field Interview)

Make entries on AF Forms 52 (Evidence Tag)

Concerning the above tasks, I am:
(mark one box)

☐	☐	☐	☐
not at all familiar with them	slightly familiar with them	moderately familiar with them	very familiar with them

If you marked the first box, please skip the next page and continue with the next group of tasks.

Use the scale below to describe the levels of training on the next page.

The trainee can perform:
0 = no aspects of the tasks independently; requires constant direction
1 = very few aspects of the tasks independently; requires nearly constant direction
2 = some aspects of the tasks independently; requires substantial direction
3 = many aspects of the tasks independently; requires some direction
4 = most aspects of the tasks independently; requires little direction
5 = nearly all aspects of the tasks independently; requires very little direction
6 = all aspects of the tasks to minimum standards without direct supervision.

Training Time (in hours)

Level of Training
(percent of full training)

Current Training Level
(the way things are now)

CLASS:______ ______

ESBI:______ ______

CDC:______ ______

OJT:______ ______(trainee)

______(trainer)

TOTAL: 100%

Ideal Training Level
(the way things should be)

CLASS:______ ______

ESBI:______ ______

CDC:______ ______

OJT:______ ______(trainee)

______(trainer)

TOTAL: 100%

Minimum Entering Background

CLASS:______

ESBI:______

CDC:______

OJT:______

Maximum Training Level

CLASS:______ ______

ESBI:______ ______

CDC:______ ______

OJT:______ ______(trainee)

______(trainer)

Sample of the final TTM Allocation Survey format. This format was used for the field test in AFS 328X4 at Keesler AFB, MS (see section 3.1 for a description of this field test). Included are the instructions, one of the task modules evaluated, and the response sheet used to record allocation decisions. Respondents used "time to train" to describe different allocations.

PURPOSE

The purpose of this questionnaire is to describe the AMOUNTS of different types of training that are, should, or could be provided for a group of tasks. Training may be through classroom instruction, correspondence courses, hands-on experience, or other types of instruction. Training efficiency can be improved if the proper "mix" of these different types of training is provided.

INSTRUCTIONS--CURRENT TRAINING

For each type of training described in the questionnaire, you are to indicate the TIME you believe is currently devoted to reach MINIMUM STANDARDS for each group of tasks. Remember, this is training to minimum standards only and does NOT mean expert or highly skilled performance. In terms of the GO/NO GO concept, this is training up to the GO level only.

Your responses should describe the current training system (the way things are now) as accurately as you can.

The example on the next page shows you what a completed questionnaire would look like.

EXAMPLE

TASKS:

Type letter from rough draft.
Type reports from rough draft.

For each type of training, please indicate the time you believe is currently devoted to reach MINIMUM STANDARDS for the group of tasks above.

TYPE OF TRAINING	Training Time Estimate (in hrs)
Classroom instruction involving lecture/discussion & related reading (most resident technical training)	2
Correspondence courses; self-paced, individual study from text (all CDCs)	1
Hands-on experience in small, supervised training groups using simulators, mock-ups, or actual equipment (most FTDs)	0
Hands-on experience on-the-job including observing others, practicing the tasks, & receiving direction (qualification & upgrade training)	5
Other, please specify:______________________________	______

Please turn to the next page and begin.

TASK MODULE 24: PERFORM AND DOCUMENT NAVIGATION EQUIPMENT MAINTENANCE ON AIRCRAFT

LOCATE PARTS OR STOCK NUMBERS IN TECHNICAL PUBLICATIONS

RESEARCH OR IDENTIFY PARTS USING ILLUSTRATED PARTS BREAKDOWNS (IPB)
MAKE ENTRIES ON AFTO FORMS 349 (MAINTENANCE DATA COLLECTION RECORD)
MAKE ENTRIES ON AFTO FORMS 350 (REPARABLE ITEM PROCESSING TAG)
OPERATE INERTIAL AND RADAR NAVAGATIONAL EQUIPMENT FOR CHECK-OUT OF ASSOCIATED AVIONIC SYSTEMS
REMOVE OR REPLACE MINOR HARDWARE ON LRU, TEST SETS OR MOCKUPS, SUCH AS KNOBS OR LAMPS
SECURE OR SAFETY LRU IN AIRCRAFT

ISOLATE MALFUNCTIONS TO ASSOCIATED AIRCRAFT EQUIPMENT

ISOLATE MALFUNCTIONS TO RELAYS

ISOLATE MALFUNCTIONS TO WIRING PROBLEMS ON AIRCRAFT

PERFORM PREVENTIVE MAINTENANCE ON INERTIAL AND DOPPLER NAVIGATIONAL SYSTEMS
REMOVE OR REPLACE RELAYS

SOLDER AVIONIC INERTIAL OR RADAR NAVIGATION SYSTEM WIRING

SPLICE AVIONIC INERTIAL OR RADAR NAVIGATION SYSTEM WIRING

REMOVE OR REPLACE AVIONIC INERTIAL OR RADAR NAVIGATION SYSTEM CONNECTORS
REMOVE OR INSTALL ACCESS PANELS

TAPE AVIONIC INERTIAL OR RADAR NAVIGATION SYSTEM WIRING

TAG OR LABEL EQUIPMENT

For each type of training, please indicate the time you believe is currently devoted to reach MINIMUM STANDARDS for the group of tasks on the opposite page.

Training Time Estimate (in hrs)

TYPES OF TRAINING

Classroom instruction involving lecture/discussion & related reading (most resident technical training) ______

Correspondence courses; self-paced, individual study from text (all CDCs) ______

Hands-on experience in small, supervised training groups using simulators, mock-ups, or actual equipment (most FTDs) ______

Hands-on experience on-the-job including observing others, practicing the tasks, & receiving direction (qualification & upgrade training) ______

Other, please specify:______________________________ ______

____

INSTRUCTIONS--IDEAL TRAINING

For each type of training described in the questionnaire, you are to indicate the time you believe should be devoted to reach minimum standards in the MOST EFFECTIVE WAY. Making the most effective use of each type of training may involve providing more of some types of training and less of others. Or it may involve keeping the same levels as the current training system.

Note: Ideal training does NOT mean providing more of all types of training, since this means you are raising minimum standards, not reaching the same standards more effectively. Ideal training does mean providing the best "MIX" of training (e.g., more of some types, less of others) to reach the SAME MINIMUM STANDARDS you described under current training.

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REMOVE OR INSTALL ACCESS PANELS

TAPE AVIONIC INERTIAL OR RADAR NAVIGATION SYSTEM WIRING

TAG OR LABEL EQUIPMENT

For each type of training, please indicate the time you believe should be devoted to reach minimum standards in the MOST EFFECTIVE WAY for the group of tasks on the opposite page. Do NOT specify more of all types of training.

TYPE OF TRAINING	Training Time Estimate (in hrs)
Classroom instruction involving lecture/discussion & related reading	______
Correspondence courses; self-paced, individual study from text	______
Hands-on experience in small, supervised training groups using simualtors, mock-ups, or actual equipment	______
Hands-on experience on-the-job including observing others, practicing the tasks, & receiving direction	______
Other, please specify: ______________________________	______

INSTRUCTIONS--MAXIMUM TRAINING OF EACH TYPE

It may be possible to completely train a group of tasks using some types of training, but not others. For example, a group of tasks which involved manual skills probably can NOT be trained to minimum standards in a classroom. Similarly, it might NOT be acceptable to completely train some tasks on-the-job without some classroom instructions on theory or safety precautions.

For each type of training described in the questionnaire, you are to indicate the time you believe that would be required to COMPLETELY train each group of tasks to MINIMUM STANDARDS. If the tasks cannot be completely trained using a particular type of training, indicate the PERCENTAGE of full training that can be provided and the time it would take to reach this level.

The example on the next page shows you what a completed questionnaire would look like.

EXAMPLE

TASKS:

Type letters from rough draft.
Type reports from rough draft.

For each type of training, please indicate the time you believe it would take to completely train the tasks above to minimum standards. If the tasks cannot be completely trained using a particular type of training, please indicate the percentage of full training that can be provided and the time it would take to reach this level.

TYPES OF TRAINING	Training Time Estimate (in hrs)	Percent of Full Training
Classroom instruction involving lecture/ discussion & related reading	3	30%
Correspondence courses; self-paced, individual study from text	3	25%
Hands-on experience in small, supervised training groups using simulators, mock-ups, or actual equipment	7	100%
Hands-on experience on-the-job including observing others, practicing the tasks, & receiving direction	2	100%
Other, please specify:______	____	____

Please turn to the next page and continue.

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REMOVE OR INSTALL ACCESS PANELS

TAPE AVIONIC INERTIAL OR RADAR NAVIGATION SYSTEM WIRING

TAG OR LABEL EQUIPMENT

For each type of training, please indicate the time you believe it would take to completely train these tasks to minimum standards. If the tasks cannot be completely trained using a particular type of training, please indicate the percentage of full training that can be provided and the time it would take to reach this level.

TYPES OF TRAINING	Training Time Estimate (in hrs)	Percent of Full Training
Classroom instruction involving lecture/ discussion & related reading	_____	_____%
Correspondence courses; self-paced, individual study from text	_____	_____%
Hands-on experience in small, supervised training groups using simulators, mock-ups, or actual equipment	_____	_____%
Hands-on experience on-the-job including observing others, practicing the tasks, & receiving direction	_____	_____%
Other, please specify:____________________ ____________________________________	_____	_____%

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