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SURVEY OF TASK ANALYSIS METHODS

by

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This survey of task analysis methods was performed as a first step in a program to advance the state of the art in methods used to identify the requirements for training devices. The survey included a review of the literature and interviews with industrial contacts. Identified task analysis techniques/methods are classified with respect to several descriptive categories (e.g., type of analysis, level of analysis, parameters used) and the procedures for application are summarized. Some government and industrial users of the

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techniques and recent system applications are identified. Based on review and analysis of the findings, a general method for task analysis on new systems is outlined and the characteristics of a good analysis are identified.

SURVEY OF TASK ANALYSIS METHODS

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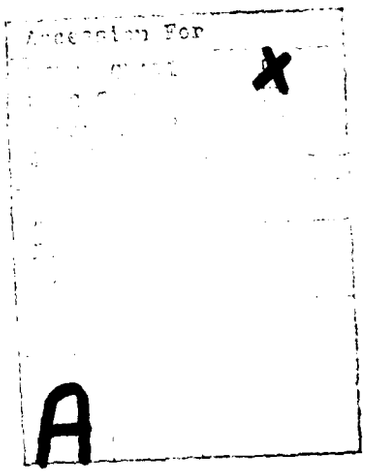

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FOREWORD

This report contains the results of the task analysis survey and constitutes Data Item 0002 AC specified in Contract No. DAHC19-78-C-0016. The work accomplished to conduct the survey is specified in Task No. 4.1.1 of the Statement of Work, Appendix "A" to the Contract.

I. INTRODUCTION

The technical objectives of this research effort are twofold. The first objective is to produce a significant advance in the methods and techniques used to analyze tasks for the development of training requirements and devices for U.S. Army systems. The second objective is to validate the effectiveness of the selected methods and techniques by actually applying them to the Infantry Fighting Vehicle (IFV) in an effort to generate training requirements and training device characteristics for the crewmen who will operate the system in tactical environments.

To achieve the first objective, the initial step is to identify the techniques available and successfully used by training specialists to analyze tasks during the development of training system requirements. To identify these techniques, a survey of representative industrial firms and government agencies was carried out by means of literature review and telephone interviews with practicing analysts in the field of training.

The literature review was extended backwards to the early fifties with emphasis given to the most recent period when task analysis began to be routinely used in training system development. The survey was directed primarily towards the identification of the best available methods and techniques for task analysis, training requirements identification and training devices characteristics specification. The "best" methods are defined as those which have been successfully applied to systems, particularly new weapon systems, and have proven to provide sufficient information for training system development in a cost-effective manner. Such methods are also defined as being systematic and providing accurate and complete information, to the extent required for training requirements analysis for U.S. Army systems.

II. BACKGROUND

Before discussing the survey, it is considered desirable to place task analysis in historical perspective and to state the nature of the problems that are being experienced by those engaged in training system development.

A. Historical Background

Task analysis has been in existence since the turn of the century. Taylor, for example, referred to task analysis in his work on scientific management (65). In the same time frame, the Gilbreths developed the first formalized method for task analysis in their work on improving industrial efficiency (21, 22). In the 1930's, industrial psychologists also employed task analysis as a tool in studying various manufacturing processes to improve production (67). In the 1950's, Miller and Folley developed task analysis techniques that allowed for human attributes in complex task performance (48, 47, 51, 50). One technique was referred to as the "task-demands analysis" which took account of the demands placed on the operator. During this same time period, others such as Dunlap and Associates, Inc., developed new techniques that were employed in both the design of complex systems (e.g., missiles, spacecraft and aircraft) and the development of training and training device requirements. Among these techniques was the Operational Sequence Diagram (OSD) which is still being employed today to analyze complex tasks (10, 66). The work of above mentioned researchers, greatly influenced the development of job-oriented training which is still in vogue today and used as a basis in most manuals dealing with training system development in both private industry and the military (e.g., TRADOC Pamphlet 350-30, AFP 50-58 and NAVAIR's MIL-T-29053).

B. Statement of Problems

Since 1960, the number of task analysis methods has increased to a point where there are almost as many methods as there are analysts working in the field of training system development. Everyone appears to have their own approach even though most generally follow the "systems approach to training" (54). Such a proliferation of methods and techniques has led many individuals to conclude that no single technique can be generated which is valid under all circumstances (54, 57, 62, 12, 19, 18, 28). Unfortunately, no one as yet appears to have sorted out this multitude of techniques and attempted to determine under what circumstances should they be applied nor has anyone attempted to identify the "best" methods in terms of such factors as cost-effectiveness and quality of required information.

These problems are precisely the ones addressed in the present survey. However, before discussing the survey, it is necessary to define the term "task analysis" since many in the field of training cannot agree on its definition (54, 15).

III. DEFINITION OF TASK ANALYSIS

There is a distinction made in training research between task description and analysis (11, 20, 49). Normally, tasks are first described and then they are analyzed to develop instructional objectives. A task description is usually defined as an account of the performance of a skilled man or experienced worker and is written in achievement language. In contrast, task analysis attempts to identify the formal properties of performance and to classify performance in behavioral categories (20). In practice, however, a logical distinction cannot be made between task description and task analysis (11), i.e., both activities interact with one another and cannot be carried out independently. For this reason, task analysis should be considered a process which is carried out early in the training system development cycle. Task analysis may then be defined operationally as the process employed to identify, describe, analyze and verify the human functions and tasks performed to operate, control and maintain a system. The specific techniques used to carry out each of the various activities in the process constitute what may be referred to as the method. The techniques therefore, are the "tools-of-the-trade" that are used to analyze tasks.

As pointed out above, both the methods and techniques employed by the training community vary widely. The use of a specific technique or class of techniques appears to depend on such factors as the nature of the system, the purpose of the analysis, the behavioral domain of the tasks and the general type of performance under examination. For example, the orientation of the analysis is usually different (e.g., tactical mission, equipment and job) depending on the purpose of the analysis even though the training program ultimately developed is job oriented. A different orientation requires that different techniques be used to conduct the task analysis process.

While a logical distinction may be made between the four activities in the task analysis process as defined above, no clear dividing line separates them, i.e., they interact with one another and cannot be carried out in a sequential step-by-step fashion. Task analysis, therefore, is an iterative process in which tasks are continuously identified, described, analyzed and verified until the analyst believes he possesses a complete and accurate "paper and pencil model" of the human functions performed in the system, together with those task parameters (e.g., criticality, difficulty level, conditions and performance standards) deemed necessary for conducting a training priority analysis, the results of which are used as a basis for developing a training system. What techniques are used, for what purpose, under what circumstances and how successfully, are key questions addressed in this survey.

IV. SURVEY METHODS

The purpose of the survey is to identify the techniques used by training specialists in carrying out task analysis within the training development process. Three methods were employed to conduct the survey. Both manual and computer searches were used to identify relevant documents in the literature. Telephone interviews with practicing training specialists presently working in the field were used to supplement the literature reviews and to obtain some indication of the problems and successes of the various techniques employed.

A. Computer Searches

Three computer data banks were searched back to approximately 1964 using such key words as "task analysis," "job analysis," "personnel training" and instructional systems." The data banks searched, were ERIC, PSYCH ABSTRACTS and NTIS accessed at Yale Medical Library in New Haven, Connecticut. The ERIC data bank yielded a total of 297 citations with abstracts; PSYCH ABSTRACTS yielded 189 and NTIS, 375 making a total of 861 documents. Of these, 63 documents were judged as being pertinent to the survey and ordered from appropriate repositories. A total of 57 documents were received for review in either the form of hard copy or microfische. Documents were read to identify the task analysis techniques used, problems encountered and the systems to which they had been applied.

B. Manual Search

Due to the limitations of data banks, the task analysis literature prior to 1964 had to be searched manually using the library facilities at Dunlap and Associates, Inc., in Darien, Connecticut. This search yielded approximately 50 documents which were considered pertinent to the survey. These were also reviewed and appropriate information extracted for inclusion in the research effort.

C. Telephone Contacts

A total of 22 individuals in the field of training system development, were contacted during the telephone survey. The questions asked were concerned with the processes used in training system development, techniques found useful for task analysis, their success and the problems encountered in actually applying the techniques. Everyone contacted was very cooperative and interested in the results of the survey. Most felt there was a need for improved techniques for analyzing tasks since training system development manuals were considered weak in this area.

V. RESULTS OF SURVEY

The survey produced a deluge of valuable information which required considerable effort to interpret and reduce to a form suitable for examination as well as for presentation in this report. Survey data are, therefore, presented in tabular form with references to the documents or person contacted. These references are arranged in lists appearing in the Appendices.

A. Task Analysis Techniques

A summary of the techniques used to carry out the task analysis process is presented in Table I.

B. Description of Techniques and Their Uses

Table II presents a summary description of the techniques used by various practitioners in the field. The table also indicates whether the technique is used to develop training requirements, training devices or both. The reader is referred to the documents in the reference list for a more thorough description of the various techniques.

C. Application of Techniques and Their Reported Success

Table III identifies the systems to which the various task analysis techniques have been applied, the system's stage of development, the focus of the analysis (e.g., operations, maintenance and support), the purpose of the analysis, who performed it and what success was achieved as judged by the analyst who performed the work. In no instance did a training analyst claim he had serious problems in carrying out the task analysis process. Unfortunately, few training systems have been validated using objective criteria which would have been a more appropriate measure of success. In the few instances where validation has actually occurred, no good description of the task analysis techniques actually used, appear in documented form. For this reason, it is difficult to determine with any degree of certitude, how successful the various techniques are in reality. Therefore, at least for the present time, we must use the judgement of the individuals who developed the training system and the instructors who use it.

D. Types and Sources of Data for Task Analysis

Table IV deals primarily with the identification and verification activities in the task analysis process. As one might suspect, the types and

Table 1. Task Analysis Techniques Used in Training System Development

TYPE	TASK ANALYSIS TECHNIQUES	FOCUS		LEVEL			TYPE		INTER-ACTION			ENVIRON-MENT			TASK FORMAT			OTHER ITEMS					PARAMETERS					
		Tactical Operations	Maintenance Support	Function	Task	Element	Single Job	Crew	Narrative	Tabular	Graphic	Ambient	Safety	Constraints	Information	Decision	Action	Job Aids/Tools	Concurrent Tasks	Skill Level	Knowledge	Location	Time Based	Criticality	Difficulty	Frequency	Duration	Standards
GRAPHIC	Operational Sequence Diagrams (OSD)	X			X	X	X	X			X				X	X	X		X			X	X				X	
	Mission Profiles	X		X								X	X	X			X						X				X	X
	Information-Decision Action Chart (IDA)	X	X		X	X		X							X	X	X						X				X	
	Link Analysis	X		X	X			X			X						X					X				X		
	Logic Tree Diagram (LTD)	X	X		X	X		X							X	X	X											
	Functional Flow Block Diagram (FFBD)	X	X	X	X			X			X						X											
	Mission Flow Chart	X		X	X			X									X											
	Time Line Chart	X			X			X			X	X	X	X			X		X			X					X	
	Behavioral Surface Analysis	X			X	X	X					X	X	X	X	X	X		X				X				X	X
	Information Flow Diagram	X			X	X		X			X	X	X	X	X	X	X		X			X						X

Table I. Task Analysis Techniques Used in Training System Development (continued)

TYPE	TASK ANALYSIS TECHNIQUES	FOCUS		LEVEL			TYPE		INTER-ACTION			ENVIRON-MENT			TASK FORMAT			OTHER ITEMS					PARAMETERS					
		Tactical Operations	Maintenance Support	Function	Task	Element	Single Job	Crew	Narrative	Tabular	Graphic	Ambient	Safety	Constraints	Information	Decision	Action	Job Aids/Tools	Concurrent Tasks	Skill Level	Knowledge	Location	Time Based	Criticality	Difficulty	Frequency	Duration	Standards
TABULAR	Task Equipment Analysis (TEA)	X	X		X	X	X			X							X										X	
	Task Analysis of Procedures	X	X		X	X	X					X			X	X	X											
	Task Analysis Form B	X	X		X	X	X				X				X	X	X					X		X			X	
	Task Analysis Form C	X	X		X	X	X				X				X	X	X					X					X	
	Position Equipment Task Summary (PETS)	X	X		X		X										X					X					X	
	Task Analysis Work Sheet (TAWS)	X	X		X	X	X				X	X	X				X					X		X			X	
	Performance Factor Form (PFF)	X	X		X	X	X										X											
	Task Listing 1	X		X	X	X	X								X	X	X							X		X		
	Task Listing 2	X			X	X	X		X						X	X	X					X		X				
	Common Component Part List (CCPL)		X		X		X										X							X				
	Task Sequence	X	X	X	X		X								X	X	X					X	X				X	

Table I. Task Analysis Techniques Used in Training System Development (continued)

TYPE	TASK ANALYSIS TECHNIQUES	FOCUS		LEVEL			TYPE		INTER-ACTION			ENVIRON-MENT			TASK FORMAT			OTHER ITEMS					PARAMETERS					
		Tactical Operations	Maintenance Support	Function	Task	Element	Single Job	Crew	Narrative	Tabular	Graphic	Ambient	Safety	Constraints	Information	Decision	Action	Job Aids/Tools	Concurrent Tasks	Skill Level	Knowledge	Location	Time Based	Criticality	Difficulty	Frequency	Duration	Standards
TABULAR (cont'd)	System Block Analysis	X	X	X	X			X									X											
	Functional Task Description	X	X		X	X	X								X	X	X	X							X	X	X	
	Behavioral Details Description	X			X	X	X								X	X	X			X	X				X	X		
	Job Data Worksheet (JDW)	X	X	X	X		X								X		X	X										X
	NOTAP Data Correlation Sheet (NDCS)		X		X		X										X	X		X							X	
	Data Correlation Sheet (DCS)		X		X		X										X			X					X	X		X
	Supplementary Job Data Worksheet (SJDW)		X		X	X	X										X											X
	Job Performance Measure Decision Sheet (JPM)		X		X	X	X						X	X			X			X				X			X	X
	Human Factors Task Analysis	X	X		X	X	X								X	X	X							X	X			
	Job Task Listing Model	X	X		X		X										X			X	X							X
	Task Decision Worksheet (TDW)	X	X	X	X	X		X[1]	X[1]	X[1]	X[1]						X		X[1]			X[1]		X	X	X	X	X

[1] Depends upon the type of task/activity description employed.

Table I. Task Analysis Techniques Used in Training System Development (continued)

TYPE	TASK ANALYSIS TECHNIQUES	FOCUS		LEVEL			TYPE		INTER-ACTION			ENVIRON-MENT			TASK FORMAT			OTHER ITEMS					PARAMETERS					
		Tactical Operations	Maintenance Support	Function	Task	Element	Single Job	Crew	Narrative	Tabular	Graphic	Ambient	Safety	Constraints	Information	Decision	Action	Job Aids/Tools	Concurrent Tasks	Skill Level	Knowledge	Location	Time Based	Criticality	Difficulty	Frequency	Duration	Standards
TABULAR (cont'd)	Task Analysis Data Base	X		X	X	X	X	X	X						X	X	X										X	
	Task Analysis Listing	X		X	X	X		X	X						X	X	X											
	Behavioral Objectives Form	X				X		X	X					X	X		X		X					X	X			
	Mission Scenario Task List	X		X	X	X		X	X						X	X	X											
	Task Analysis Record (TAR)	X			X			X				X	X	X	X		X			X	X			X	X		X	
	Job Inventory Duty-Task List		X		X		X										X										X	
	Task Analysis Form (TAF)	X			X	X		X							X	X	X				X	X		X				
	ATF Form 1		X		X		X								X	X	X			X	X							
	ATF Form 2		X		X		X								X		X			X	X				X			X
	Job Data Worksheet		X		X	X	X					X	X	X			X			X								X
	Data Consolidation Form		X		X		X										X											X

Table I. Task Analysis Techniques Used in Training System Development (continued)

TYPE	TASK ANALYSIS TECHNIQUES	FOCUS		LEVEL			TYPE		INTER-ACTION			ENVIRON-MENT			TASK FORMAT			OTHER ITEMS					PARAMETERS					
		Tactical Operations	Maintenance Support	Function	Task	Element	Single Job	Crew	Narrative	Tabular	Graphic	Ambient	Safety	Constraints	Information	Decision	Action	Job Aids/Tools	Concurrent Tasks	Skill Level	Knowledge	Location	Time Based	Criticality	Difficulty	Frequency	Duration	Standards
TABULAR (cont'd)	Task Inventory Summary Sheet		X		X	X	X					X														X		
	Physical Demands Form	X	X		X	X	X					X	X	X			X										X	
	Preliminary Task/ Equipment List (PTL)		X		X	X	X										X											
	Job Data Worksheet Resources List		X		X		X								X		X	X						X				
NARRATIVE	Task Analysis of Continuous Feedback Skills	X			X	X	X						X				X					X						X
	Position Description	X	X		X	X	X					X	X	X			X					X		X			X	X
	Job Description	X	X		X	X	X					X	X	X			X											
	Intellectual Load Analysis	X		X	X		X										X				X	X		X				
	Training Reqs Analysis and Crew Position Responsibilities	X			X			X	X								X				X							X
	Sequence and Task Analysis	X			X			X			X				X	X	X		X			X	X	X	X		X	
	Critical Factors and Skills/Knowledge Requirements	X			X	X		X	X						X		X			X	X			X				

Table I. Task Analysis Techniques Used in Training System Development (continued)

TYPE	TASK ANALYSIS TECHNIQUES	FOCUS		LEVEL			TYPE		INTER-ACTION			ENVIRON-MENT			TASK FORMAT			OTHER ITEMS					PARAMETERS					
		Tactical Operations	Maintenance Support	Function	Task	Element	Single Job	Crew	Narrative	Tabular	Graphic	Ambient	Safety	Constraints	Information	Decision	Action	Job Aids/Tools	Concurrent Tasks	Skill Level	Knowledge	Location	Time Based	Criticality	Difficulty	Frequency	Duration	Standards
NARRATIVE (cont'd)	Job Modeling	X		X	X			X	X			X		X			X			X	X							X
	Goal Analysis	X			X		X										X											

Table II. Summary Descriptions Of Task Analysis Techniques, Their Application And Principal Users

TECHNIQUES	SUMMARY DESCRIPTION	Training Reqm'ts	Training Devices	USERS	REFERENCES
Operational Sequence Diagrams (OSD)	This technique presents information-decision-action sequences that a system or its component subsystems will undergo in order to attain prescribed mission objectives. It employs both symbolic and verbal material to effect a pictorial-scenario display which systematically structures the tasks to be performed. It has been used successfully to establish sequence of operations requirements between subsystem interfaces at various levels of system analysis to identify difficult or error-like situations that can be traced to inadequate hardware, procedures or communication link construction, to establish requirements for training programs and devices, to detect operator overload, and to provide information relevant to the design of controls, displays and workplace layout.	X	X	Dunlap and Associates, Inc. FMC Corp.	5, 10, 32, 34, 40, 46, 62, 66
Mission Profile	The Mission Profile graphically depicts the various phases of a mission plotted against time. The position of the system vehicle in space and environmental conditions are sometimes included in the profile.	X		FMC Corp.	43
Information-Decision Action Chart (IDA)	The IDA chart is a symbolic-verbal representation that describes tasks in terms of information-decision-action units. The tasks are sequenced vertically and their relationship in time is shown against a time line that runs from top to bottom. A scenario appears on the chart which is number coded to the symbol and provides verbal descriptions of what occurs in each unit. The chart may be used to describe the tasks performed by one or more operators and, if the latter, it will show the relationships and time sharing activities occurring between them.	X		HRB-Singer	66
Link Analysis	A Link Analysis Diagram illustrates the communications links between various operators and subgroups within a team during a typical mission. The strength (frequency) of the links between operators is indicated by the width of the lines; i.e., wide lines indicates strong links. The relative widths of the lines are usually derived from performance data using a simulator.		X	General Dynamics/ Electric Boat Division	29

Table II. Summary Descriptions Of Task Analysis Techniques, Their Application And Principal Users (continued)

TECHNIQUES	SUMMARY DESCRIPTION	Training Reqm'ts	Training Devices	USERS	REFERENCES
Logic Tree Diagram	This technique captures complex tasks which require branching at a number of decision points. The analysis is a graphic illustration of the tasks which are to be performed by system personnel.	X	X	FMC Corp.	4, 56, PC-22
Functional Flow Block Diagram (FFBD)	A Functional Flow Block Diagram depicts the flow of operations and decisions that are allocated to the human and to the equipment within a system. This analysis results in a list of functions that, when further broken down to the task level, have training implications.	X	X	FMC Corp.	44
Mission Flow Chart	The Mission Flow Chart provides a pictorial representation of a typical mission consisting of nominal mission activities (those activities common to all missions) and tactical activities (those activities which are unique within a mission). The first evolution of the flow chart identifies major operator activities. This level of activity identification is designated as EVENT level activities. A second iteration of the flow is then accomplished to further expand each of the event level activities in terms of crew TASKS which comprise the EVENT and the incremental STEPS taken to accomplish each TASK.		X	Grumman Aerospace Corp.	8
Time Line Chart	In this technique, the tasks are identified, the time and coordination requirements for the tasks, and any adverse conditions surrounding performance are noted. Each task and the operators are listed; time lines are shown to indicate the period of time consumed by each task. Coordination between and among people is shown by diagonal arrows and wavy lines (a dashed line indicates intermittent coordination). Any adverse conditions (i.e., environmental or situational factors which degrade task performance) are also recorded.		X	U.S. Naval Training Equipment Center	4, 9, 45

Table II. Summary Descriptions Of Task Analysis Techniques, Their Application And Principal Users (continued)

TECHNIQUES	SUMMARY DESCRIPTION	Training Reqm'ts	Training Devices	USERS	REFERENCES
Behavioral Surface Analysis	This technique is used to develop a taxonomy of tasks for system operations. It describes the task elements and their sequence as performed by the operator(s) in carrying out various functions during a mission. The cues, mental action and motor action are identified and described for each task element in the sequence. Such factors as environmental conditions and other constraints influencing performance are also described together with other system parameters such as speed, weapons, etc. This technique also includes a pictorial representaion of the vehicle in space to support the narrative description and sequence of the tasks.	X	X	Design Plus	42
Information Flow Diagram	This technique depicts the flow of information without respect to time or to the particular persons processing the information. It is particularly helpful in a "single thread" analysis of information flow relative to a specific system.		X	Goodyear Aerospace Corp.	24
Task-Equipment-Analysis (TEA)	The Task-Equipment-Analysis is a tabular representation of tasks and subtasks, the personnel and equipment involved, the displays, decisions, actions, and feedback present, and the frequency and duration of time involved in performance. This form of presentation and its content has been used by USAF and modified slightly by HRB-Singer to show critical values related to displayed information.	X		USAF American Institute for Research HRB-Singer	66
Task-Analysis of Procedures	This technique, consisting of two major steps, first identifies gross tasks and analyzes the displays or input features, and, second, analyzes the subtasks, emphasizing the control action or response aspects of the tasks. The display analysis covers such variables as task-relevant cues to initiate the task, the critical values or stimulus differences for discrimination, the alternative choices the display may present, and the characteristic errors or malfunctions that might occur. The response analysis covers similar features and, in addition, identifies response adequacy (feedback) and the objectives criteria of response adequacy.	X		American Institute for Research	47

Table II. Summary Descriptions Of Task Analysis Techniques, Their Application And Principal Users (continued)

TECHNIQUES	SUMMARY DESCRIPTION	Training Reqm'ts	Training Devices	USERS	REFERENCES
Form B and Form C_1	Both the B and C_1 forms are tabular techniques for recording task and task-related information and were utilized by contractors on the Minuteman program. Form B is used to describe operational tasks. Form C_1 describes maintenance tasks. Both forms identify a function, the tasks and equipment required to implement that function, the facilities requirements and personnel information regarding skills, time to perform, number of people, and critical values.	X		BSD contractors on "Minuteman"	1, 25, 26
Position-Equipment Tasks Summary (PETS)	The PETS is a record and report by work area of the relationships between personnel actions and end items of equipment. Indenture of end items of equipment is carried to the lowest level necessary in order to identify significant differences in personnel actions. The summary is used as a tool for ensuring compatibility among type and number of personnel required, allocation of tasks, training programs and equipment and review of spares provisioning.	X		BSD contractors on "Atlas"	36
Task Analysis Work Sheet (TAWS)	The TAWS contains information related to tasks, personnel, equipment, environment, and training and are perhaps the most inclusive of all T/A forms reviewed. The worksheet is used to furnish detailed task analysis information for: human factors engineering evaluation of equipment operation and maintenance requirements; development of technical manuals; training equipment design; training course material; and operation and maintenance checklists.	X		BSD contractors on "Atlas"	36
Performance Factor Form (PFF)	The Performance Factor Form is a record form that lists performance dimensions identified in the system and the implications of these factors for training.	X		American Institute for Research	17

Table II. Summary Descriptions Of Task Analysis Techniques, Their Application And Principal Users (continued)

TECHNIQUES	SUMMARY DESCRIPTION	Training Reqm'ts	Training Devices	USERS	REFERENCES
Task Listing 1	Task Listing 1 is the process of analyzing the human functions performed in a system into component major tasks. A listing of all tasks performed by each of the team members is compiled. This listing forms the foundation for all subsequent system analyses. The task listing begins with subject matter expert (SME) walking through the phases of a typical mission step-by-step. An instructional psychologist (IP) and an instructional technologist (IT) join the SME and together work on identifying those tasks that are to be completed for each phase. A standard outline format is usually used to show the relationship between tasks and to allow proper deletions and to show insertions with a maximum of flexibility and a minimum of reorganization.	X		Courseware, Inc.	33
Task Listing 2	Task Listing 2 combines, in a simplified format, information derived from several sources. It defines the tasks to be evaluated in terms of the following parameters: task type and criticality; the person(s) with whom the system operator interacts in the performance of his tasks; the reason for the interaction and the criticality of the interaction to the operator.		X	General Dynamics Electric Boat Division	30
Common Component Part List (CCPL)	A Common Component Part List (CCPL) utilizes action verbs such as "remove, replace, troubleshoot, inspect, test, clean, perform" and a system task list as a basis for analysis. The task and parts list is constructed in the form of a matrix which can be used to rate, reduce and analyze the number of tasks.	X		U.S. Naval Education and Training	35
Task Sequence Analysis	Task Sequence Analysis begins with an identification and sequential ordering of the most pertinent functions and tasks performed by system personnel. Working with a system mock-up, these tasks are first written in the form of a script and distributed to subjects who perform a series of "dry run" rehearsals. An HFE, using paper, pencil and stopwatch, records such task parameters as time, position and duration which are used as inputs for training system development.	X	X	FMC Corp.	45

Table II. Summary Descriptions Of Task Analysis Techniques, Their Application And Principal Users (continued)

TECHNIQUES	SUMMARY DESCRIPTION	Training Reqm'ts	Training Devices	USERS	REFERENCES
Task Analysis Work Sheet (2)	The Task Analysis Work Sheet is used in the Task Sequence Analysis and contains a sequence of tasks which have been previously identified as part of system operations. Tasks are listed in logical sequence.		X	FMC Corp.	43
System Block Analysis	A System Block Analysis is a sequential listing of major blocks of tasks or system operations into which the system can be partitioned.		X	U.S. Naval Training Equipment Center	4, 9
Functional Task Description	Functional Task Description defines the activities and interrelationships within tasks. This technique determines the time to perform tasks, the activities within tasks, the proportion of attention each activity requires of the operator, the contingencies (i.e., things that may disturb normal performance such as equipment malfunction, human error, unusual external situations) and any adverse conditions that apply to an individual task. Six classes of task activity may be identified: procedure following, continuous perceptual-motor activity, monitoring, communicating, decision-making or problem-solving, and non-task related activity.		X	U.S. Naval Training Equipment Center	4, 9, 62
Behavioral Details Description	Behavioral Details Description is a highly detailed level of task description. Estimates are made of trainee capability to perform the tasks, the difficulty of the training problem associated with each task, and the level of performance that can be expected after training. It is assumed that this approach enables a precise description of the relevant tasks in a system and provides the information necessary to make basic decisions about the gross features of whatever the ultimate training program may be.		X	U.S. Naval Training Equipment Center	4, 9, 62

Table II. Summary Descriptions Of Task Analysis Techniques, Their Application And Principal Users (continued)

TECHNIQUES	SUMMARY DESCRIPTION	Training Reqm'ts	Training Devices	USERS	REFERENCES
Job Data Work Sheet (JDW)	The purpose for a JDW is to provide a sequence detailing every task required to perform a job. It will usually begin at the system level and continue down to the part level as the system is carried through analysis breakdown. All tasks performed by personnel are recorded on the JDW. In addition, the JDW includes the conditions under which the man performs the task, the cue(s) that initiates the task, and standards which specify the acceptable quality of performance to which the task must be performed in the job environment. The JDW also lists all the resources required to do each task. References provide "how-to" procedures along with safety and tag-out directions where applicable. Tools and support materials specify those tools and other items such as grease or safety tags which the job incumbent needs to accomplish the task. Support equipments detail those items such as vacuum cleaners or shorting probes without which the incumbent could not perform the task.	X		U. S. Naval Education and Training	35
NOTAP Data Correlation Sheet (NDCS)	The NOTAP Data Correlation Sheet is used as a support document to aid a subject matter expert in the recording of information in the "SME Judgment" area of the data correlation sheet (DCS). The structure of the NOTAP data correlation form varies according to what is determined to be the best or most valid use of the NOTAP data for each rating analysis. In order to obtain the most valid interpretation and use of available NOTAP data, the input of the SME is mandatory. The primary NOTAP data used are: a job description or a list of duties and tasks with the percent of performance by a group of operators; who and/or how many members of a particular rating use specific pieces of equipment; the percentage of members and time spent performing each NOTAP duty/task; levels of involvement for each task.	X		U. S. Naval Education and Training	35

Table II. Summary Descriptions Of Task Analysis Techniques, Their Application And Principal Users (continued)

TECHNIQUES	SUMMARY DESCRIPTION	Training Reqm'ts	Training Devices	USERS	REFERENCES
Data Correlation Sheet	The purpose of the Data Correlation Sheet (DCS) is to determine which tasks on a Job Task Inventory (JTI) should be trained and to recommend where that training should take place.	X		U. S. Naval Education and Training	35
Supplementary Job Data Work Sheet (SJDW)	The Supplemental Job Data Work Sheet (SJDW) is utilized to list and expand upon the tasks/elements of a system. The SJDW can be termed a multi-purpose form, as it is completed differently to meet various system requirements.	X		U. S. Naval Education and Training	35
Job Performance Measure Decision Sheet (JPM)	A Job Performance Measure (JPM) is an assessment tool used to determine whether an individual operator can perform a task to the standards required on the job. It is written in the form of a test and it includes a test statement, standards for successful completion, directions, and other required information.	X		U. S. Naval Education and Training	35
Human Factors Task Analysis	This technique is employed when there is reason to believe that one or more elements of task performance will place high behavioral demands on an operator. Perceptual, judgmental, internal stress and motor behavior demands are critically assessed on a three point scale. Findings from this analysis may indicate a need for special training requirements or possible modification reassignment of a task.	X		FMC Corp.	14

Table II. Summary Descriptions Of Task Analysis Techniques, Their Application And Principal Users (continued)

TECHNIQUES	SUMMARY DESCRIPTION	Training Reqm'ts	Training Devices	USERS	REFERENCES
Job Task Listing Model	This technique creates a listing of tasks for a system by asking experienced incumbents what they do. Probing interviews are often used to assure reasonable completeness and accuracy of the task statements. This process has often been difficult to apply, however, when the job is non-procedural or not oriented to hardware operation or maintenance.	X		HumRRO Corp.	2
Task Decision Worksheets (TDW)	A Task Decision Worksheet is a detailed description of a system's tasks, their activities, and their associated standards of performance. Three distinct parts are required for a complete statement: (1) Identifying Information, (2) Training Factors, and (3) Task Activity Description and Supporting Information. There are four format forms which may be selected for task description: outline, decision table/flow chart, time-line or tabular columns. The format that is selected will depend on the nature of the task and its activities.	X		U.S. Air Force	31
Task Analysis Data Base	The Task Analysis Data Base is a hierarchy of behavioral units called task elements. The hierarchy consists of at least four and sometimes five levels. This inductive process groups task elements to form tasks, which in turn are grouped to form functions. Mission segments, the topmost level of the hierarchy, consist of groups of functions. Task elements represent the stimulus-response characteristics of a behavioral unit action sequence to be analyzed and are of the form: Initiation Cue-Action Verb-Control/Display-Completion Cue. The Initiation Cue is the stimulus complex, the existence of which is pre-requisite to the activity. The Action Sequence is the major activity of the behavioral unit. This activity consists of an action verb and a control or display. The Completion Cue is the final condition which marks the end of the behavioral unit being analyzed.	X		Calspan Corp.	53

Table II. Summary Descriptions Of Task Analysis Techniques, Their Application And Principal Users (continued)

TECHNIQUES	SUMMARY DESCRIPTION	Training Reqm'ts	Training Devices	USERS	REFERENCES
Task Analysis Listing	A Task Analysis Listing documents the job that must be performed by each crew member. It provides the task descriptions in standardized format and terminology, along with commentary which elucidates conditions and enabling activities that are critical to the task.		X	Calspan Corp.	64
Behavioral Objectives Form	The Behavioral Objectives Form is a synopsis, in mission-oriented terms, of the information that is relevant for the specification of training objectives, including the performance criteria and conditions under which the behavior must be demonstrated.		X	Calspan Corp.	64
Mission Scenario Task List	A Mission Scenario Task List aids the generation of job task descriptions specific to the performance requirements of an operational environment. This consists of a typical sequence of major events that would take place within a system mission. The task analysis effort begins by establishing a hierarchy for describing operator behaviors during a typical mission. The hierarchy includes three levels of description, defining each phase of a system in terms of major events, the tasks which comprise the events, and finally, the steps which describe the incremental actions an operator must take to complete a task.		X	Grumman Aerospace Corp.	8
Task Analysis Record (TAR)	This technique is an analysis of the training requirements related to tasks. It is conducted via a series of interviews with SMEs. The Task Analysis Record Sheet (TAR) is the form which is used to collect these data.		X	Grumman Aerospace Corp.	8

Table II. Summary Descriptions Of Task Analysis Techniques, Their Application And Principal Users (continued)

TECHNIQUES	SUMMARY DESCRIPTION	Training Reqm'ts	Training Devices	USERS	REFERENCES
Job Inventory Duty-Task List	A Job Inventory Duty-Task List is an open or free-response questionnaire which gives the user freedom in responding to questions about jobs. It allows for a complete and thorough response to questions and has a low demand upon the user because it reduces the danger of overlooking certain responses or the necessity of minimizing the number of responses.	X		U.S. Army	37
Task Analysis Form (TAF)	A Task Analysis Form distinguishes among the different classes of tasks an operator needs to perform. It is usually a classification of training objectives which pose different requirements for training devices to satisfy those objectives.		X	Grumman Aerospace Corp. Bethpage, N. Y.	8
ATF Form 1	The ATF Form 1 is used to document step-by-step maintenance instructions in the absence of an adequate data base. An adequate data base is defined as sequential maintenace instructions covering a maintenance task, to the activity level. Information on environmental constraints, performance criteria and resources (tools) is also included in the form.	X		Air Training Command	52
ATF Form 2	The ATF Form 2 is used to document descriptions and establish training requirements. For those tasks for which training requirements are identified, it lists behavioral requirements, media, conditions and criteria under which these requirements must be met.	X		Air Training Command	52
Job Data Worksheet	This technique structures the details of a particular system into its component functions and tasks. Flexibility is allowed for, depending upon the degree of detail needed by the analyst.	X		U.S. Army	37
Data Consolidation Form	This form serves to consolidate system data. Tasks are rated according to established criteria, e.g., criticality, difficulty and performance standards.	X		U.S. Army	37

Table II. Summary Descriptions Of Task Analysis Techniques, Their Application And Principal Users (continued)

TECHNIQUES	SUMMARY DESCRIPTION	Training Reqm'ts	Training Devices	USERS	REFERENCES
Task Inventory Summary Sheet	A Task Inventory Summary Sheet lists selected tasks for training. It then summarizes the collected data upon which selection decision were based.	X		U.S. Army	37
Physical Demands Form	This form is used an an aid in collecting and recording facts about a job to be performed. Basically, it serves to identify and analyze what the task calls for in the way of physical activity and the environmental or working conditions under which the task will be performed. Derivatives of this form have been used in personnel subsystem test and evaluation.	X		Government, Industry, Dunlap and Associates, Inc.	38, 55, 58
Preliminary Task/ Equipment List (PTL)	The purpose of the Preliminary Task/Equipment List (PTL) is to form the basis of a job task inventory. The function of such an inventory is to provide the means for organizing the tasks of a system into a sequential hierarchy. The PTL is usually a collection of index cards graphically arranged in order to maximize clear task visibility and easy monitoring and manipulation for sequencing of tasks.	X		U.S. Navy Education and Training	35
Job Data Worksheet Resources List	The Job Data Worksheet Resources List describes all cues, standards, tools, references, support equipment, support material, test equipment and other conditions needed to perform a job.	X		U.S. Navy Education and Training	35
Task-Analysis of Continuous Feedback Skills	This is a narrative description of skills involved in a continuous feedback type of task (e.g., tracking) which involves continuous adjustments to continuously changing stimulus conditions, part of which are a consequence of the operator's adjustments. The varibles identified relate to the display, decisions, controls and the feedback mechanism. Characteristic errors and malfunctions are also identified.	X		American Institute for Research	47

Table II. Summary Descriptions Of Task Analysis Techniques, Their Application And Principal Users (continued)

TECHNIQUES	SUMMARY DESCRIPTION	Training Reqm'ts	Training Devices	USERS	REFERENCES
Position Description	The Position Description (sometimes called a job description) is a record of all the facts that describe the content of the position. This description includes job operations, duties and tasks, equipment and material used, working conditions, time estimates of performance and statements of qualities or abilities that an operator must possess to perform the job in a satisfactory manner.	X		U.S. Air Force	13
Job Description	Job Descriptions vary in detail depending upon the needs of the analyst. However, most descriptions contain sufficient information to identify a job by describing its scope, purpose, and content and contain a detailed description of the work to be performed to cover the "what," "how," and "why" of the job.	X		Industry, Government, Military	55, 58
Intellectual Load Analysis	An Intellectual Load Analysis indicates two types of information: aspects of the job which impose the heavies' intellectual load (training requirements); and the specific kinds of intellectual activities involved when a man is heavily loaded (training content). It is based on Guilfords' structure-of-intellect (SI) model. This technique identifies the specific tasks performed by an operator which are then fitted into the SI framework, and estimates of task difficulty are made on a scale between 0 and 100.	X		U.S. Naval Training Equipment Center	27, 60
Training Requirements Analysis and Crew Position Responsibilities	This technique serves to identify crew responsibility, conditions, and performance, and describes casualty sequences for a particular system. It is used as a basis for casualty analysis employing the Sequence and Task Analysis technique.		X	Goodyear Aerospace Corp.	24

Table II. Summary Descriptions Of Task Analysis Techniques, Their Application And Principal Users (continued)

TECHNIQUES	SUMMARY DESCRIPTION	Training Reqm'ts	Training Devices	USERS	REFERENCES
Sequence and Task Analysis	This technique is used to demonstrate the recognition, decision making and corrective actions involved with casualties. For recognition, the initiated conditions, detection and verification activities are described. For decision making, the system characteristics, system status and data collection are described. For corrective action, the basic system sequence and representative alternative courses of action are described. An information flow diagram is usually included to indicate the results of the analysis.		X	Goodyear Aerospace Corp.	24
Critical Factors and Skills/Knowledge Requirements	This technique defines the critical factors, skills and knowledge requirements for accomplishing a particular task.		X	Goodyear Aerospace Corp.	24
Job Modeling	A Job Model specifies: the broad job functions derived from appropriate system characteristics; the general behavioral science considerations appropriate to the analysis of each broad function; information categories which fully explicate each job function, the appropriate sources of information, and the procedures for gathering such information. The development of a job model proceeds from knowledge of,or assumptions about, the system and includes the identification of alternative courses of action and their consequences. It also includes a specification of the behavioral processes required for effective performance on the job.	X		HumRRO Corp.	65
Goal Analysis	Goal Analysis is used to identify the performances in command, managerial and supervisory areas which demonstrate achievement of system goals expressed in mission terms. A goal is defined as "a statement describing a broad or abstract intent, state, or condition." Goal analysis is a heuristic approach to task identification involving translation of abstract, subjective conditions in an effort to identify the main performances that go to make up the meaning of the goal.	X		U.S. Air Force Institute of Technology	6, 41

Table III. Task Analysis Techniques Applied To Development Of Training For More Recent Systems

SYSTEM NAME	SYSTEM DESCRIPTION	TASK ANALYSIS TECHNIQUES*	DEVELOPMENT STAGE			FOCUS		PURPOSE		TRAINING ANALYST	SUCCESS		REF'S.
			New	Mod.	Exist.	Oper.	Maint.	Training Reqm'ts	Training Devices		Yes	No	
	Submarine Fire Control Team Trainer	• Link Analysis • Task Listing • Operations Sequence Diagram (OSD)	X			X			X	General Dynamics-Electric Boat	X		29
EA-6B	Navy Tactical Jamming Aircraft	• Task Listing 1		X		X		X		Courseware	X		33, PC-15
IFV	Army Infantry Fighting Vehicle	• Operations Sequence Diagram (OSD) • Functional Flow Block Diagram (FFBD) • Task Sequence • Task Listing 2 • Logic Tree Diagram • Human Factors Task Analysis	X			X	X	X	X	FMC Corp.	X		14, 43, 44, 45, 46, 56, PC-22
P3C/VSX	Navy ASW Aircraft	• Intellectual Load Analysis	X			X			X	NTEC	X		59
	Submarine Casualty Control Simulator Training Device	• Training Requirements Analysis and Crew Position Responsibilities • Sequence and Task Analysis		X		X			X	Goodyear	X		24

*Appellations as they appear in the reports or referred to by the interviewee.

Table III. Task Analysis Techniques Applied To Development Of Training For More Recent Systems (continued)

SYSTEM NAME	SYSTEM DESCRIPTION	TASK ANALYSIS TECHNIQUES	DEVELOPMENT STAGE			FOCUS		PURPOSE		TRAINING ANALYST	SUCCESS		REF'S.
			New	Mod.	Exist.	Oper.	Maint.	Training Reqm'ts	Training Devices		Yes	No	
B-1	Air Force Heavy Bomber	• Task Analysis Data Base	X			X		X		Calspan	X		53, PC-3
E-2 C	Navy AEW Aircraft	• Task Analysis Listing • Behavioral Objective Form		X		X			X	NTEC	X		64
A-6E	Navy Carrier Based Attack Bomber	• Mission Scenario • Task List • Task Analysis Record (TAR) • Mission Flow Chart • Task Analysis Form (TAF)	X			X			X	Grumman Aerospace Corp.	X		8
F-4E	Air Force Multi-Role Fighter Aircraft	• Behavioral Surface Analysis	X			X		X	X	Design Plus	X		PC-8, 42
LAMPS MK III	Navy ASW Helicopter	Reference: MIL-T-29053		X		X	X	X	X	IBM	X		PC-1 PC-2 PC-16
AIS	Automated Instructional System	Reference: AFP 50-58 • Task Description Work Sheet • Task Diagrams • Decision Flow Charts • Time Line Charts • Task List	X			X	X		X	McDonnell-Douglas	X		PC-4 PC-5 31

*Appellations as they appear in the reports or referred to by the interviewee.

Table III. Task Analysis Techniques Applied To Development Of Training For More Recent Systems (continued)

SYSTEM NAME	SYSTEM DESCRIPTION	TASK ANALYSIS TECHNIQUES*	DEVELOPMENT STAGE			FOCUS		PURPOSE		TRAINING ANALYST	SUCCESS		REF'S.
			New	Mod.	Exist.	Oper.	Maint.	Training Reqm'ts	Training Devices		Yes	No	
AEGIS	Navy Shipboard Missile System	Reference: MIL-STD-1379A	X				X	X		RCA - Moorestown	X		PC-6 PC-20
B-1	Air Force Heavy Bomber	Modified Techniques Identified in AFP 50-58	X				X	X		3306 Test and Evaluation Squadron	X	P	PC-10 PC-12 PC-13, 52
F-16	Air Force Air Superiority Fighter	Modified Techniques Identified in AFP 50-58	X				X	X		3306 Test and Evaluation Squadron	X		PC-10 PC-12 PC-13, 52
	Training Programs for Radioman and Interior Communications Ratings	Reference: Draft Supplement to NAVEDTRA 106A • Job Data Work Sheet • Supplemental Job Data Work Sheet • Data Correlation Sheet • NOTAP Data Correlation Sheet • SJDW Criteria Matrix • Job Performance Measure Decision Sheet • Evaluative Criteria Matrix					X	X		Naval Education and Training Support Center-Pacific	X		PC-14 PC-17, 35

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Table III. Task Analysis Techniques Applied To Development Of Training For More Recent Systems (continued)

SYSTEM NAME	SYSTEM DESCRIPTION	TASK ANALYSIS TECHNIQUES*	DEVELOPMENT STAGE			FOCUS		PURPOSE		TRAINING ANALYST	SUCCESS		REF'S.
			New	Mod.	Exist.	Oper.	Maint.	Training Reqm'ts	Training Devices		Yes	No	
	Financial Management Education	• Goal Analysis • Task Description and Analysis • Job Analysis			X	X		X		U.S. Air Force Institute of Technology	X		6

*Appellations as they appear in the reports or referred to by the interviewee.

Table IV. Types And Sources Of Data For Task Analysis

TYPES OF DATA REQUIRED FOR TASK ANALYSIS	POTENTIAL SOURCES OF DATA			
	New System		Existing or Modification	
	Collection	Verification	Collection	Verification
System Description System Missions Mission Scenarios and Phases Mission Functions	Major Command PMO/SPO	Major Command PMO/SPO	Major Command Army Regulations Field Manuals System Analysis (original)	Major Command Army Regulations Field Manuals
Personnel Data (QQPRI) Task Descriptions Task Parameters • Criticality • Difficulty • Duration • Standards • Ambient • Percent Performing • Percent Time Spent • Skills and Knowledges • Time Lag • Prior Learning • Hazards and Constraints	Major Command PMO/SPO Contractor: • Interviews • Task Analyses • Operator Manuals • Maintenance Manuals SME Interviews	Major Command: • Interviews • Questionnaires Contractor: • Interviews • Questionnaires Simulation Analyses of Similar Systems SME Interviews	Major Command: • Interviews • Questionnaires Army Regulations Field Manuals TRADOC Schools Training Courses and Materials Technical Orders OSR's SOP's Training Standards Task Analyses (original)	Major Command • Interviews • Questionnaires Personnel Survey • Interviews • Questionnaires • Observation (experts) SME (Instructors/ Supervisors) • Interviews • Questionnaires

PMO/SPO = Program Management Office/System Project Office
QQPRI = Quantitative and Qualitative Personnel Requirement Information
SME = Subject Matter Experts
SOP = Standard Operating Procedures
OSR = Occupational Survey Report

sources of information vary depending on the stage of system development as shown in the table. Sources of information for task analysis has traditionally been one of the most difficult problems for the analyst.

VI. DISCUSSION OF RESULTS

The results of the survey clearly indicate that many task analysis techniques are available and successfully used to develop training system requirements. "Successful use," however, does not mean that their application has resulted in effective training systems, nor does it mean that they are efficient in terms of the time and effort expended to produce them. These criteria of success remain unknown quantities which have not been measured in any objective manner. In those few instances where careful comparisons have been made between traditional and proceduralized system approaches to training, the specific techniques employed by the analyst are not adequately identified and no valid conclusions can be made concerning their success or failure (7, 63). In spite of this dilemma, however, useful information can be drawn from the results of the survey.

A. Variations of Techniques

Virtually, all practitioners contacted in the field of training system development stated that they generally follow the instructional system development (ISD) process, in past years referred to as the proceduralized systems approach to training. This process is described in the multitude of ISD manuals that have come into vogue in recent years. Almost all practitioners have found it necessary to modify the task analysis techniques appearing in these manuals to fit the specific situation at hand. This dependency of techniques was stated quite clearly as follows:

> "There is no single way of doing task analysis. It depends on the situation--maintenance, operations, new job, update of existing job, etc....." (PC-16)

Other factors identified as having a significant influence on the selection and use of techniques include the stage of system development (e.g., new emergent system vs. existing system), the behavioral domain being examined (e.g., command functions vs. proceduralized skills) and the number of individuals comprising the operating team. Consideration of such factors can provide a framework for classifying techniques, evidence of which is seen in the tables of survey results appearing above.

B. Classification of Techniques

The classification of task analysis techniques is presented in Table V. Each cell in the table represents a different method consisting of different techniques used for accomplishing one activity in the task analysis process. One factor not shown in the table is the number of individuals

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Table V. Classification Of Task Analysis Techniques And Their Application

SYSTEM DEVELOPMENT STAGE	FOCUS OF ANALYSIS															
	Tactical Operations								Equipment Maintenance							
	Command Functions				Operator Functions				Supervisory Functions				Service Functions			
	Ident.	Descr.	Anal.	Verif.	Ident.	Descr.	Anal.	Verif.	Ident.	Descr.	Anal.	Verif.	Ident.	Descr.	Anal.	Verif.
New System																
Modified System																
Existing System																

Ident. - Identification
Descr. - Description
Analy. - Analysis
Verif. - Verification

who perform in the system. This factor is important since the techniques used to describe and analyze system functions and tasks performed by a team are usually quite different from those used for analyzing a single job.

C. Tactical Operations and New Systems

Perhaps, the most difficult analysis to perform is one dealing with the operation of a new emergent system involving many crew members who must work as a team in a variety of mission environments. The IFV would fall into this category.

Such a system is difficult to deal with because there is little information on which to base the analysis. There are usually few, if any, similar systems to compare it with and what systems engineering information does exist usually ignores the human functions that must be accomplished to achieve mission objectives. Systems engineering documents adequately describe the mission objectives and the hardware comprising the system but do not adequately identify and describe the functions and major tasks that crew members must perform to accomplish each phase of the mission (61). Consequently, in many instances the training analyst must conduct his own systems analysis to obtain such information and to ensure no critical tasks remain unidentified during the task analysis process.

In addition, personnel information of the QQPRI type is usually not available to the analyst even in preliminary form. Hence, the analyst must also determine or at least confirm who will operate the system and what functions and tasks they will perform in the system. As a consequence, the training analyst's initial activity is not task or job analysis as implied by most ISD manuals but, rather, job specification using human factors systems analysis techniques. Whether systems analysis should fall within the realm of the training analyst's domain or not, is another issue that will not be addressed here. Most ISD manuals assume that systems information on operator functions is readily available and the analyst need only start with job or task analysis for each operator position. Such is almost never the case when he must deal with a new emergent system.

D. Task Analysis for New Emergent Systems

The general methods and techniques for conducting task analysis for situations involving new systems and their employment are illustrated in Table VI. The inputs and outputs of each activity in the process are also indicated in the table. The method is a general one based on the survey results. The specific techniques and format used by the analyst is unimportant at this point. For example, it probably makes little difference whether a tabular or graphic technique is used to describe tasks, provided

Table VI. General Method For Initial Analysis of Tasks Performed By Crewmen In New Systems

TASK ANALYSIS ACTIVITY	DATA INPUT	GENERAL METHOD	DATA OUTPUT	OUTPUT FORMAT
Task Identification	System Engineering Specifications Mission Descriptions Mission Analysis Data System Analysis Data	Perform human factors systems analysis.	Functions and major tasks for each mission by phase Allocation of functions and major tasks to operator level	Functional Flow Chart depicting hierarchy of tasks to operator level in graphic format
Task Description	Function Flow Charts Equipment Descriptions Human Factors Design Data Simulation Tests SME and Contractor • Interviews • Questionnaires Similar System Data	Extract task data from sources and organize under identified functions and major tasks. Express tasks in behavioral terms.	Hierarchy of operational tasks described to element level Description of crew interaction	Task Lists in tabular format Crew interaction by task in tabular format
Verification	Task Data Charts and Tables SME and Contractor Interviews Major Command Review PMO Review	Review and check accuracy and completeness of all task descriptions with SME, contractor and approving agencies.	Accurate and complete description data	Same as input but revised and updated
Basic Analysis	Verified Task Description Data	Establish task parameters (e.g., performance standards, criticality, conditions, etc.).	Behavioral objectives	Behavioral objectives list in tabular form
Training Priority Analysis	Behavioral Objectives	Determine training priority of each task using indices of scaled task parameters.	Summary of tasks rated in terms of training priority	Training priorities by task in tabular form

the description is accurate, complete, readable and permits each item to be traced back to its origin in the mission.

E. Level of Detail

The level of detail required for task analysis is a key issue which was mentioned by many practitioners during the telephone survey. One of the major complaints about the documented ISD processes is that their application results in a deluge of paperwork containing detailed information which is largely ignored by the analyst in developing training system requirements (54). This is reported to be one primary reason why so many have found it necessary to modify the documented ISD processes. Some have stated that "to set out to make a complete description of performance, on the grounds that this is bound to include the training information required is to court disaster." (3)

Based on the results of the survey, it is quite apparent that, initially, tasks should only be described to a level sufficient for accomplishing a training priority analysis. Such a level is usually reached when tasks performed by individual crewmen are first identified in the breakdown. This level of detail occurs well before the "pushbutton stage."

F. Training Priority Analysis

Once the tasks for individual operators are identified and expressed in behavioral terms, the analyst has the opportunity to conduct a training priority analysis. He first must make realistic estimates of those factors having a significant influence on the performance of each task. These factors include whether the task has already been learned or not, the performance standards, criticality, difficulty, frequency and environmental constraints affecting performance. Many of these factors can be scaled and mathematically combined to obtain a priority index for each task (23). Tasks having a high priority are considered candidates for further analysis and possible inclusion in the training program. Such tasks are sometimes referred to as the "training tasks." Only those tasks having high priorities are then further described in greater detail and the rest ignored for the remainder of the analysis.

Training priority analysis, of course, may be carried out one or more times during subsequent stages of the task analysis process as a means of identifying task elements requiring special treatment or emphasis in the training program. Those high priority training tasks identified as involving a high level of coordinated crew interaction, for example, may require detailed description and analysis for the development of team training requirements. The analyst, of course, needs to be aware of such techniques and know when and how to apply them. The level of detail, therefore, is dictated by the results of the training priority analysis which

is carried out as early as possible in the process. In this way, no a priori decision on detail need be made and the effort spent on analyzing unimportant tasks reduced to an absolute minimum.

G. Characteristics of a Good Task Analysis

It is not the purpose of this initial effort and report to recommend specific methods or techniques for the conduct of the task analysis process. However, the survey did yield some suggestions which should be mentioned and considered in making specific recommendations. Such recommendations will be the subject of the next technical report on this research effort. Many characteristics of a good task analysis were briefly mentioned above. Based on the survey, the following characteristics were mentioned quite often.

1. The analysis should be mission oriented, otherwise critical tasks may remain unidentified and not included in the training program.

2. Decision rules for identifying training tasks should be applied early in the process to eliminate the need for describing all tasks in great detail.

3. All tasks, their parameters and decisions regarding training priority should be traceable back to the mission and its environments.

4. All data must be presented in a form that can be easily read and understood for review and verification.

5. Sources of data employed in the analysis should be identified.

6. All data and decisions should be verified and approved at major milestones in the process.

7. Procedures should be systematic and easily followed by an inexperienced training analyst.

8. Assumptions made, particularly during the initial system analytic phase, should be stated and approved prior to their use.

9. Tasks should be expressed in behavioral terms.

10. Training priority analysis should only be carried out by an experienced and skilled analyst who is thoroughly familiar with the system.

11. Alternative techniques should be made available for performing detailed analyses of critical training tasks such as those involving a high degree of crew interaction.

12. Specifications should be written and imposed on system contractors to ensure task data are available in a timely fashion for the task analysis effort (16).

This last suggestion might be considered as having little or nothing to do with task analysis itself. However, experience has shown that the training analyst too often spends an inordinate amount of time identifying and formatting task descriptions using guesswork and assumptions which he knows already exist in the contractor's files. Such information is used by the contractor's human factors engineers to design system equipment. If it were mandatory that such information be provided to the PMO in a specific format as a contractual data item input, the training analyst's job could be greatly reduced and duplication of effort minimized. As a consequence, the analyst could spend more of his time on actual development of the training system which is certainly better utilization of his special talents.

VII. SUMMARY AND CONCLUSIONS

The results of the survey indicate that there are numerous task analysis methods and techniques available and used successfully to develop training system requirements. Their employment depends quite heavily on the situation and the focus of the analysis. Nevertheless, given a single situation, no agreement exists on exactly which methods and techniques to use; although most will agree that a systems approach to training is warranted and that the resultant training system should be job oriented.

Most practitioners in the field have found it necessary to modify the task analysis procedures appearing in the numerous manuals on instructional system development. These modifications were reported as necessary to meet their specific needs and to reduce the deluge of paperwork that application of ISD procedures produce when carried out faithfully. In spite of this dilemma, there does appear to be a generalized method for analyzing crew functions performed in new emergent systems operating in tactical environments. Such a system is difficult for the analyst to deal with and one which characterizes the IFV. Recommendations regarding the specific techniques comprising this method will be the subject of subsequent efforts under this contract. These recommendations will be developed in view of the suggestions made by practitioners contacted during the survey and uncovered during the literature search.

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