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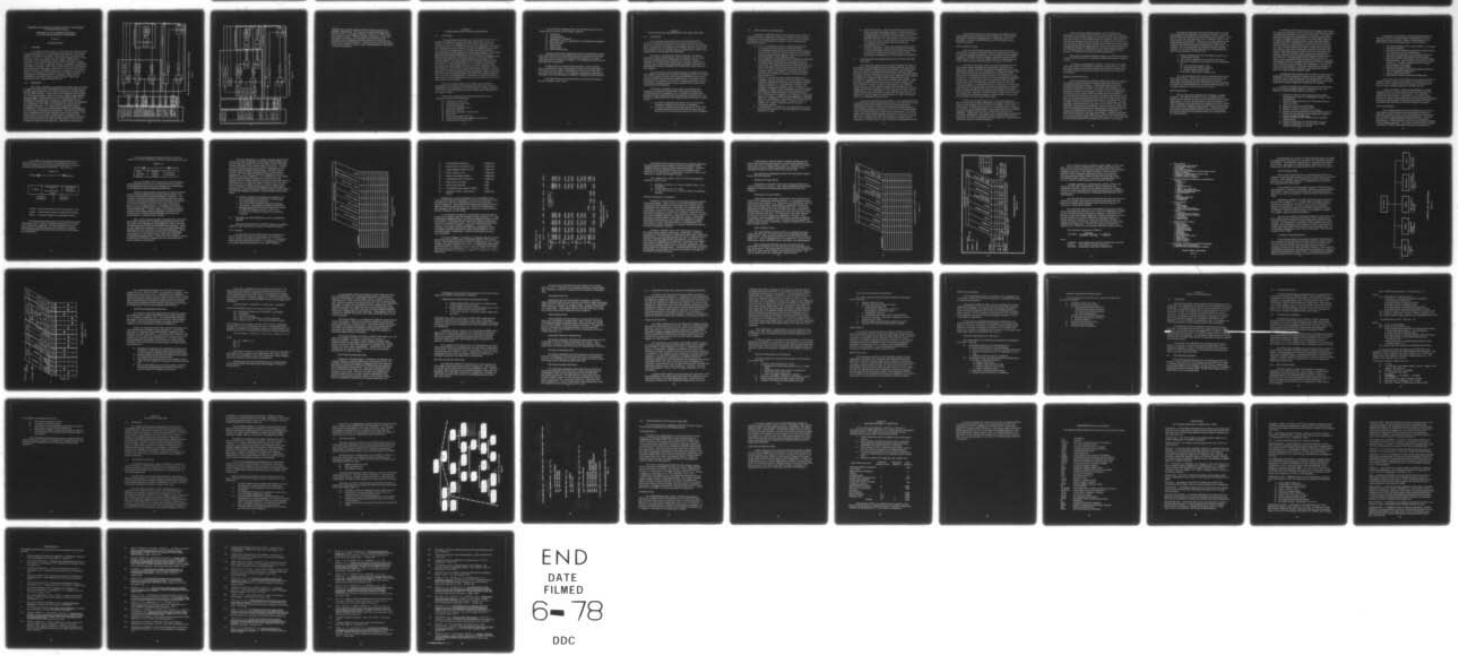

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INTEGRATION AND APPLICATION OF HUMAN RESOURCE TECHNOLOGIES IN WEAPON SYSTEM DESIGN:

PROCESSES FOR THE COORDINATED APPLICATION OF FIVE HUMAN RESOURCE TECHNOLOGIES

By

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March 1978
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This interim report was submitted by Dynamics Research Corporation, 60 Concord Street, Wilmington, Massachusetts 01887, under contract F33615-77-C-0016, project 1959, with Advanced Systems Division, Air Force Human Resources Laboratory (AFSC), Wright-Patterson Air Force Base, Ohio 45433. Dr. William B. Askren, Personnel and Training Requirements Branch, was the work unit scientist.

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This technical report has been reviewed and is approved for publication.

GORDON A. ECKSTRAND, Director
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The five human resource technologies are defined as: maintenance manpower modeling (MMM), instructional system development (ISD), job guide development (JGD), system ownership costing (SOC) and human resources in design trade-offs (HRDT).

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coordinated human resource technology
design option decision trees
human resource in design trade-offs
instructional system development
job guide development
life cycle costing
maintenance manpower modeling
system ownership costing
task analysis
training
weapon system acquisition

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

The four basic activities of the coordinated human resource technology are described. The first is the consolidated data base development which processes source data. The second is the integrated requirements and task analysis (IRTA) which determines human resource requirements. The third is ISD/JGD product development. The fourth is the impact analysis which provides human resource and cost data on any specific configuration or alternative. It is through this activity that CHRT may influence the selection of design, maintenance operations and support alternatives.

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AFHRL-TR-78-6(I)	Integration and Application of Human Resource Technologies in Weapon System Design: Coordination of Five Human Resource Technologies
AFHRL-TR-78-6(II)	Integration and Application of Human Resource Technologies in Weapon System Design: Processes for the Coordinated Application of Five Human Resource Technologies
AFHRL-TR-78-6(III)	Integration and Application of Human Resource Technologies in Weapon System Design: Consolidated Data Base Specification for the Coordinated Application of the Five Human Resource Technologies

SUMMARY

PROBLEM AND OBJECTIVE

The five human resource technologies are maintenance manpower modeling (MMM), instructional system development (ISD), job guide development (JGD), system ownership costing (SOC) and human resource in design trade-offs (HRDT). Traditionally, they have been applied individually at various times during the weapon system acquisition process. Although one intuitively recognizes similarities in activities and data requirements among these technologies, these similarities had never been confirmed, explored, or exploited. Furthermore, it appears that exploitation of these similarities early in weapon system acquisition may allow human resource considerations to affect design.

The Advanced Systems Division of the Air Force Human Resources Laboratory (AFHRL) has, therefore, initiated a two-phase effort to integrate and apply the five technologies to the weapon system acquisition process as the coordinated human resource technology (CHRT). This volume is one of three which document the Phase I effort. The objective of this phase was two-fold. One, to develop and integrate the relationships among the five technologies in order to create a totally coordinated technology, CHRT, for application throughout the acquisition process. Two, to determine the data input requirements and to prepare a specification for a consolidated data base (CDB) which will support the integration and application of the CHRT in a weapon system application program. The objective of Phase II is to apply the results of this study to a weapon system acquisition program.

The specific objective of this volume is to present the four basic activities within the CHRT process as they have been initially conceived. These activities were identified in the first volume and are:

1. Development of the consolidated data base
2. The integrated requirements and task analysis
3. Instructional system and job guide product development
4. The impact analysis.

It is important to re-emphasize, however, that these activities are conceptually described. The feasibility of these activities will be determined and alternative steps will be developed in Phase II (15 October 1977 - 15 April 1979). The entire report will then be updated upon completion of Phase II. The result will describe CHRT as a demonstrated methodology rather than a concept.

APPROACH

The approach taken was as follows. Having developed the CHRT methodology and identified the basic activities, the same team of researchers developed the detailed steps necessary to accomplish each activity. Existing procedures from the technologies were used where possible. New procedures were devised only where none existed or where the existing ones needed to be supplemented. The basic workability of each procedure was verified on sample data for a UHF radio.

RESULTS AND CONCLUSIONS

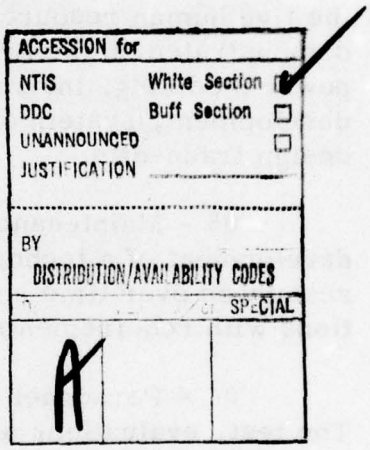
This effort resulted in the identification and definition of the steps integral to the four basic activities.

The development of the consolidated data base consists of many steps, most of which are initial steps in the human resource technologies. For example, the initial steps of MMM: equipment identification; the comparability analysis; and maintenance action network development all become steps in data base development. Additionally, the initial steps from HRDT: development of the system design option decision trees (DODT); selection of critical subsystems; and development of subsystem DODTs, are also part of the data base development.

The integrated requirements and task analysis is defined and described. Initially a requirements analysis, it integrates elements of MMM, ISD, and JGD, and it facilitates the prediction of human resource requirements in the conceptual and validation phases. For maintenance, the basic MMM comparability analysis is used during this time frame as the prime input, and is supplemented with additional task and personnel data. For operations, an operations task listing is prepared which is also supplemented with task and personnel data. An on-equipment integrated task analysis is then accomplished during full scale development and addresses both maintenance and operations. The maintenance portion of this task analysis is used for MMM as well as ISD and JGD.

The ISD and JGD product development efforts are also initiated during the conceptual phase. The products at this stage are the ISD/JGD concepts. The validation phase results in the ISD/JGD plans and the full scale development phase in the ISD/JGD program. The final product of the ISD/JGD program is a coordinated set: the instructional system and the job guide manuals.

Finally, a rationale and logic has been developed to determine the human resources and cost impact of any design, maintenance, operations, or support alternative. Knowledge of this human resource and cost impact allows these considerations to influence the selection of the alternative. This output of CHRT is called the impact analysis.



PREFACE

The Advanced Systems Division of the Air Force Human Resources Laboratory has initiated project 1959, Advanced System for Human Resources Support of Weapon Systems Development, to demonstrate the technical feasibility of methodologies geared to reduce the system ownership cost of new weapon systems. The Advanced Medium STOL Transport (AMST) is being used as the test case. Project 1959 is divided into the following four work units.

01 - Analysis of Resource Utilization of a Present Operational System - Data related to human resource utilization and life cycle costing (LCC) on a similar past weapon system (the C-130E) is gathered and presented. Availability of such data is determined.

02 - Integration and Application of Human Resource Technologies in Weapon System Design - A methodology for integrating the five human resource technologies is developed and subsequently demonstrated on the AMST. The technologies are maintenance manpower modeling, instructional system development, job guide development, system ownership costing, and human resources in design trade-offs.

03 - Maintenance Personnel Availability Analysis - The development of a technique to estimate the availability of human resources over time and of procedures to align availability expectations with requirements. AMST requirements data will be considered.

04 - Personnel Subsystem Test, Evaluation, and Validation - The test, evaluation, and validation of the results of the studies conducted under work units 01, 02, and 03.

Although this total effort is presently directed toward demonstration on a specific weapon system, it is expected that it will be applicable to any system, military or non-military, and to major system modifications as well.

This study which represents work unit 02 was performed under contract F33615-77-C-0016 by the Systems Division of Dynamics Research Corporation, 60 Concord Street, Wilmington, Massachusetts 01887. Technical direction was provided by the Advanced Systems Division, Air Force Human Resources Laboratory (AFHRL), Wright-Patterson Air Force Base, Ohio. Appreciation is extended to Dr. Gordon A. Eckstrand, Director of the Advanced Systems Division and Dr. Ross L. Morgan, Chief of the Personnel and Training

Requirements Branch for their contributions and encouragement. Major Duncan L. Dieterly was the project director and Dr. William B. Askren was the work unit scientist on unit 02, Integration and Application of Human Resource Technologies in Weapon System Design.

Many individuals throughout the Department of Defense and industry contributed their ideas and opinions to this effort. Of special note, however, were the members of the Advanced Systems Division Advisory Team who contributed both in their specific areas of expertise and in the total development of CHRT. These individuals and their areas of expertise are Mr. Robert N. Deem, maintenance manpower modeling; Dr. Garry A. Klein, instructional system development; Dr. Donald L. Thomas, job guide development; Mr. Harry A. Baran, system ownership costing; Dr. William B. Askren, human resources in design trade-offs; and Dr. Lawrence E. Reed, consolidated data base. Major Robert J. Pucik of the AMST Program Office provided the interface with the AMST acquisition effort. Appreciation is also extended to Dr. John P. Foley, Jr., for sharing his view of job guide development and the instructional system/job guide relationship.

This report, consisting of three volumes, is the product of Phase I. The three volumes contain the rationale for integrating the human resources technologies and the methodology for applying them as CHRT. They show how CHRT can be used to influence design and the selection of maintenance, operations, and support alternatives. The evolution of CHRT from elements of existing technologies is discussed. Additionally, specific descriptions are provided of the CDB, the integrated requirements and task analysis (IRTA), the development of ISD and JGD products, and the impact analysis which allows the evaluation of alternative designs and the identification of excessive human resource utilization. The three volumes are:

Integration and Application of Human Resource Technologies in Weapon System Design: Coordination of Five Human Resource Technologies for Application, AFHRL-TR-78-6, Vol. I;

Integration and Application of Human Resource Technologies in Weapon System Design: Processes for the Coordinated Application of the Five Human Resource Technologies, AFHRL-TR-78-6, Vol. II;

Integration and Application of Human Resource Technologies in Weapon System Design: Consolidated Data Base Specification for the Coordinated Application of the Five Human Resource Technologies, AFHRL-TR-78-6, Vol. III.

The first volume initially describes the basic weapon system acquisition process. It then discusses the human resource technologies as presently applied and their interfaces with each other. Next the potential for an expanded application of these technologies within the weapon system acquisition process is described. Finally, CHRT is described as an integration of the human resource technology elements and its proposed role in each acquisition phase is detailed.

The second volume describes the basic activities and associated data inherent in the CHRT methodology. This volume is a detailed expansion of the first. The major processes of CHRT are defined as the consolidated data base development, the integrated requirements and task analysis, product development, and the impact analysis.

The third volume specifies the requirements for the consolidated data base which supports CHRT. It describes the input and output data, the associated sources, the processes, and the interfaces of the CDB with the major process of CHRT.

It should be noted, however, that this total report is the product of the development phase and represents the CHRT methodology as conceived. The methodology will be demonstrated during Phase II and this report updated to reflect the results of the demonstration. The updated version therefore will describe a proven methodology which can be practically applied during system acquisition.

Stimulated by Department of Defense intensitifed efforts to reduce future weapon system operating and support (O&S) costs, the AFHRL initiated this study to develop a methodology for applying the five primary technologies in an integrated fashion. The results of this first phase indicate that application of a new coordinated human resource technology has the potential for significantly reducing the O&S costs of new weapon systems. Examples of additional benefits that accrue are: (a) synergistic effects of the interaction of the technologies regarding improving personnel performance and reducing personnel costs, (b) potential cost savings through single management of the five HR technologies, and (c) potential cost savings through sharing common data sources.

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Integration and Application of Human Resource Technologies in Weapon System Design:

Processes for the Coordinated Application of the Five Human Resource Technologies

Section 1

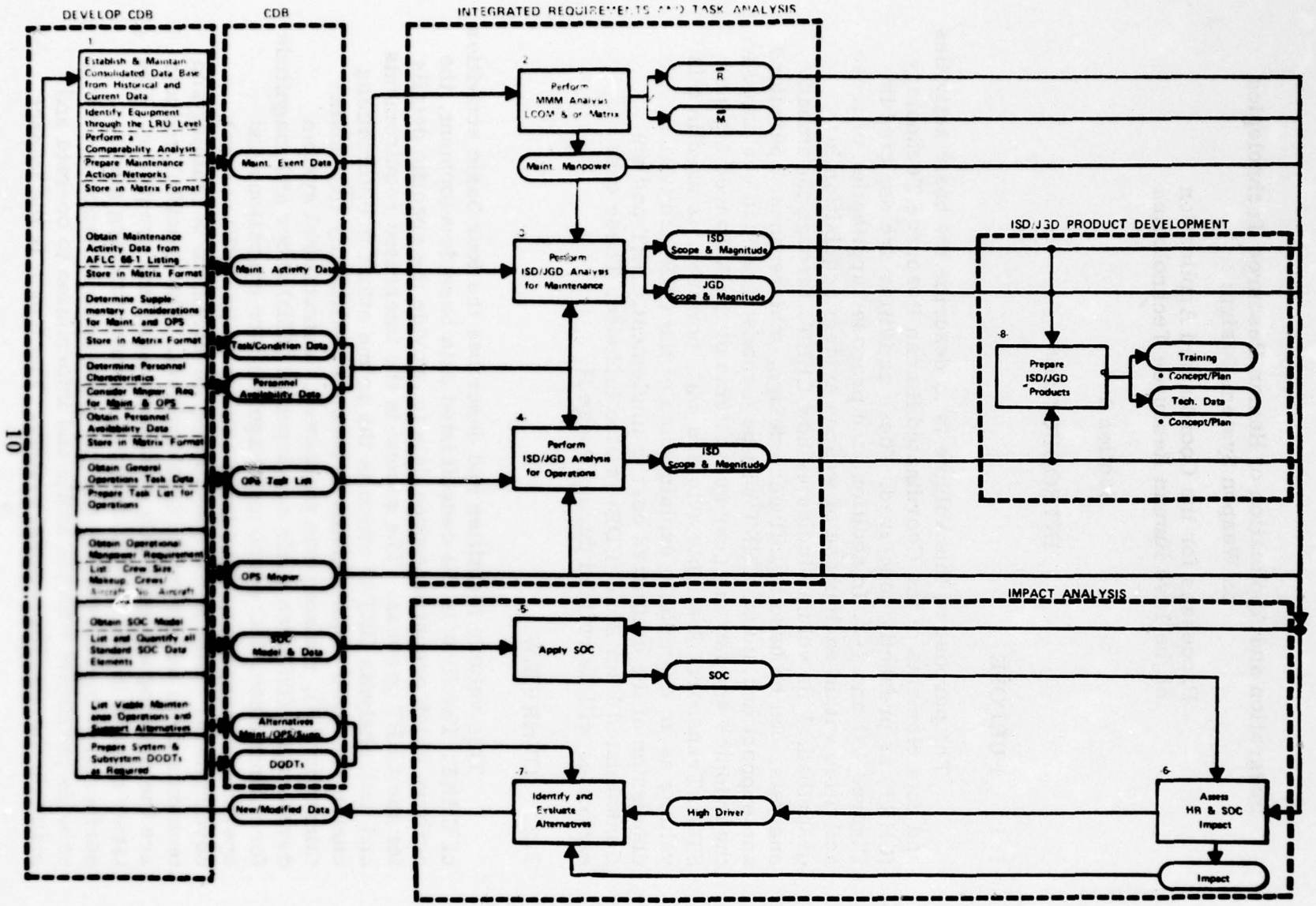
INTRODUCTION

1.1 PURPOSE

The purpose of this volume is to describe the basic activities and data elements of the Coordinated Human Resource Technology (CHRT) as presently conceived. These activities are depicted in Figures 1-1 and 1-2. In addition, the proposed application of these activities within each phase of weapon system acquisition is described. This volume indicates how CHRT, through the impact analysis, can be used to influence design, maintenance, operations, and support decisions. CHRT will be demonstrated and evaluated on the avionics and landing gear subsystems of the Advanced Manned STOL Transport. A simple avionics unit, however, is used in this volume as an example to explain some of the CHRT activities. A discussion of the estimated cost to implement CHRT and the Consolidated Data Base (CDB) is also included. These cost estimates will be refined during Phase II.

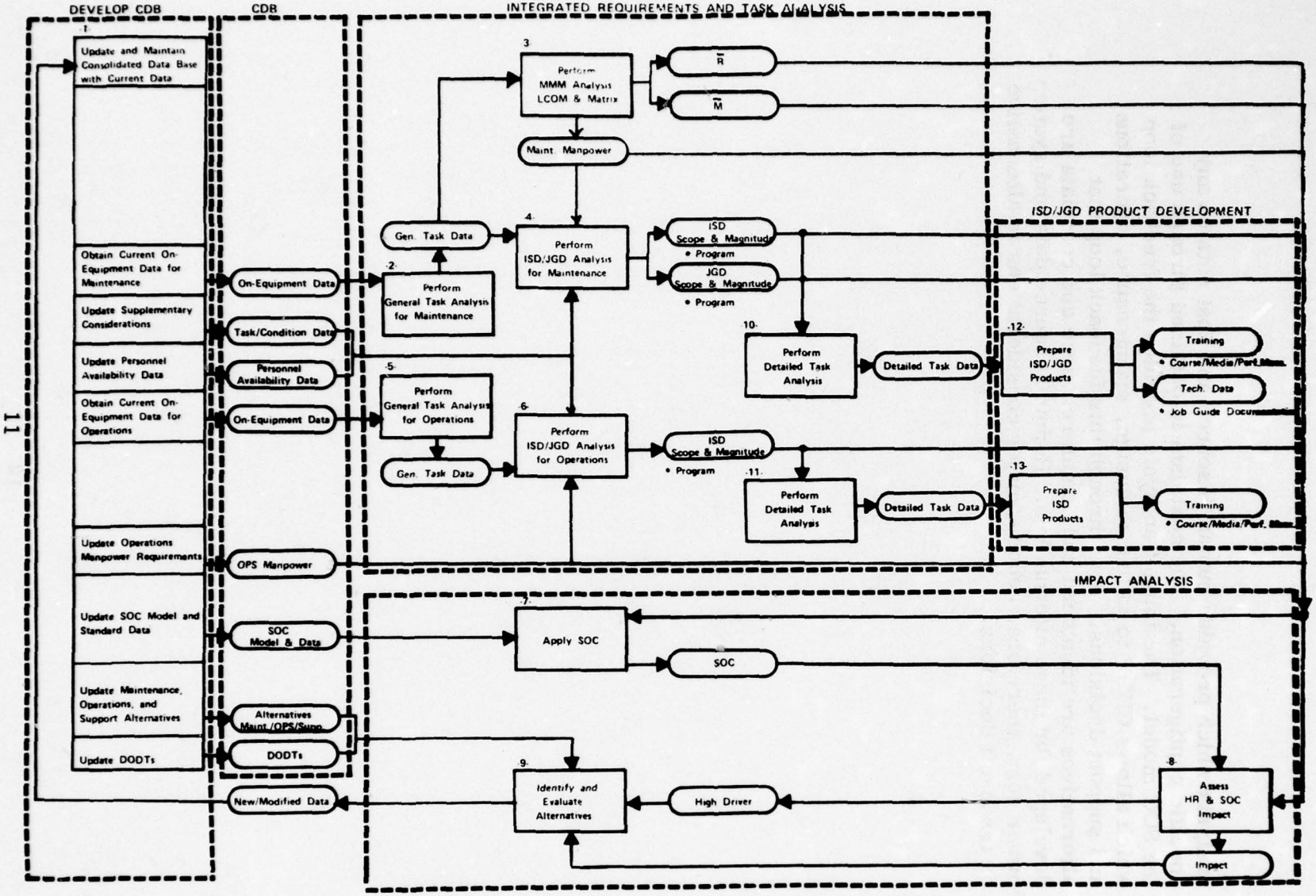
1.2 OVERVIEW

This volume identifies and describes the four basic activities of CHRT. The first is the consolidated data base development, the activity which prepares source data to provide the specific details for the CHRT process. The second is the integrated requirements and task analysis (IRTA) which is the prime effort in determining human resource requirements in terms of reliability ($\overline{R}$), maintainability ($\overline{M}$), maintenance manpower, instructional system development (ISD)/job guide development (JGD) scope and magnitude for maintenance, ISD scope and magnitude for operations and operations manpower. The third activity is ISD/JGD product development. This is the coordinated development of training and tech data from an integrated task analysis. The specific products are the training and tech data concepts, plans and programs. The latter results in the specific training course, training media, performance measurements and job guide documentation needed to provide personnel with the skills and information to operate and maintain the specific weapon system. The fourth is the impact



THE CHRT PROCESS (CONCEPTUAL & VALIDATION PHASES)

Figure 1-1



THE CHRT PROCESS (FULL SCALE DEVELOPMENT PHASE)

Figure 1-2

analysis which provides human resource and cost data on any specific configuration. The cost data is obtained through use of the SOC model. The impact analysis provides the feedback loop which allows CHRT to influence design, maintenance, operations and support decisions. It is through this feedback loop that alternatives are identified and human resource and cost data are developed for these alternatives. Human resource data and system owner cost, therefore, become major considerations in alternative or trade-off decisions.

Section 2
CONSOLIDATED DATA BASE DEVELOPMENT

2.1 OVERVIEW

The consolidated data base is the cornerstone of CHRT and is initially established during the conceptual phase for a reference system and all basic configurations that will be considered. The reference system is the system(s) that the new acquisition will replace and consequently must be shown to be less cost/effective in the long run. The basic configurations may involve completely different, competing systems using different technologies, designs, and concepts, and even those being investigated for and by different services. Historical information is the prime source of data and is updated with current information as it becomes available. At the start of the validation phase, the CDB consists of the reference system and one or more basic configurations approved for continued development. The latter are called baseline systems. A current system is also established for each baseline. The current system reflects the baseline modified to reflect each change made during validation. A similar procedure is followed during full scale development. Upon completion of the full scale development phase the CDB should consist predominately of current on-equipment data. Dependency on historical data is thus reduced over the acquisition life cycle and is minimal as the system enters the production phase.

Most of the initial steps in the various human resource technologies are utilized in the development of the CDB. This was described to a limited degree in the first report. The data developed is then used in the integrated requirements and task analysis and in the impact analysis.

During the conceptual and validation phases, the CDB development results in the following:

- Maintenance event data
- Maintenance activity data
- Task/condition data
- Personnel availability data
- Operations task list
- Operations manpower requirements
- SOC model
- Standard and unique SOC data
- Maintenance/operations/support alternatives
- Design option decision trees

The CDB is then supplemented with the following data which results from the IRTA and the impact analysis:

- Reliability
- Maintainability
- Maintenance manpower
- ISD/JGD scope and magnitude for maintenance operations
- SOC estimates
- Impact data
- High drivers
- New/modified data

During the full scale development phase the maintenance event and activity data and the operations task list is replaced by on-equipment data which is used in the integrated task analysis. All other CDB data initially developed is updated. The supplemental data is then also updated as necessary.

In this report the content (data elements) of each data file (e.g., maintenance event, maintenance activity) will be described as it is drawn from the CDB or developed as part of an activity other than data base development. For example, maintenance manpower is developed from the maintenance manpower modeling (MMM) analysis.

The CDB content and structure will be described in detail in the third volume of this series.

Section 3
THE INTEGRATED REQUIREMENTS AND TASK ANALYSIS

3.1 OVERVIEW

The integrated requirements and task analysis (IRTA): predicts and quantifies the human resource parameters; provides the basic information required for the training and tech data concept, plan, and program; and results in the detailed task data required for the development of the training course, training media, performance measurement, and job guide documentation.

During the conceptual and validation phases, the IRTA is basically a requirements analysis used to size and cost the human resource requirements and to quantify the effects of various alternatives. It draws general task data from MMM, maintenance records, and an operations comparability analysis. Historical data supplemented wherever possible with current data is the basis for this analysis.

During the full scale development phase an integrated general task analysis is performed on current on-equipment data. The results are used as inputs to MMM and the ISD/JGD decision which in turn provide updated human resource requirements. The integrated task analysis is then continued to provide the detailed task data required to develop the training course, media, performance measurement, and job guide documentation.

The IRTA is expanded in each phase and provides both predictive and product-oriented data. During the conceptual and validation phases the emphasis is on the prediction and becomes product-oriented during full scale development and production. The integrated requirements and task analysis described herein is unique in that

- It results in integrated predictive data not previously available during the early phases of acquisition
- It assures a single-source task analysis for MMM, ISD, and JGD requirements and products thus assuring both optimization and coordination among the three disciplines.

3.2 TASK RELATED DEFINITIONS

In Report I, task was described, in general, as an action or reaction related to equipment. Before proceeding further with this integrated requirements and task analysis section, a more rigorous and broader set of definitions is required. These definitions are provided as follows:

- Task - A composite of related activities (behaviors) performed by an individual and directed toward accomplishing a specific amount of work within a specific work context. These activities usually occur in temporal proximity with the same displays and controls and have a common purpose. Each task has a goal.
- Task Analysis - An analytic process employed to determine the specific behaviors required of a human in a man-machine system. It involves determining, usually on a time basis, the detailed performance required of men, the nature and extent of their interactions with the machine and the effects of environmental conditions and malfunctions. It is the breakdown of behaviors into simple elements of perceptions, decisions, memory storage, motor output, etc.
- Behavior - Any human action generally defined by a stimulus (cue) and response. A basic stimulus-organism-response constituent of behavior comprising the smallest logically definable set of perceptions, decisions, and responses required to complete a task. Involves, for example, identifying a specific signal on a specific display, deciding on a single action, activating a specific control and noting the feedback signals of response adequacy.
- Cue - A stimulus to a response. For example, a cue could consist of a meter reading, physical appearance, flashing light, etc. Responses to cues consist of such activities as turning a knob, setting a switch, reading a value on a display, etc. Often a response can be a cue for a succeeding response.
- Task Statement - A statement of the behavioral elements (in action verb form), the cues and equipment description involved in a task.

- General Task Data - Those task statements necessary to make a decision regarding manpower requirements and the applicability of training courses, media, performance measurement, and job guide documentation (i.e., the ISD/JGD decision). For maintenance, the task level would be to the LRU (e.g., repair LRU) but would not include development of the specific task statements that encompassed the task.
- Detailed Task Data - Those task statements detailed to the level necessary to make the final ISD/JGD decision, to make trade-offs within the instructional system itself, and finally to develop the products: course, media, performance measurement, and job guide documentation.

3.3 THE INTEGRATED REQUIREMENTS AND TASK ANALYSIS CONCEPT

The integrated requirements and tasks analysis for CHRT is an evolutionary and integrated activity utilizing general task data to determine manpower, ISD and JGD requirements, and detailed task data to develop the final ISD and JGD products. Within the CHRT process it may be reiterated many times during any acquisition phase to quantify the effect of design, maintenance, operations, and support alternatives on manpower and ISD/JGD requirements. CHRT provides this capability earlier than previously was possible. CHRT also allows identification of high drivers, excessive requirements which highlight the need to consider alternatives. An excessive requirement is a human resource demand directly related to the design, operations, or support concept which exceeds some criteria established for the weapon system. For example, the mean time to repair (MTTR) any item within a system may be thirty minutes. If a particular design or support concept results in a forty-five minute MTTR, it is considered a high driver.

During the conceptual and validation phases, general task data is obtained from MMM comparability analyses and maintenance action networks, historical maintenance records, and an operations comparability analyses. During the full scale development phase a task analysis is performed as part of CHRT from on-equipment data and is coordinated between maintenance and operations. The initial output of this task analysis is general task data which is used as the input to the MMM and the ISD/JGD analyses. In all phases, general task data is supplemented with data regarding existing courses, resources, tech data, and the characteristics of available personnel.

Detailed task data is the final output of the integrated task analysis performed during full scale development. It is required during this phase of the weapon system acquisition cycle, and thereafter, to refine the ISD/JDG mix, and to develop the final ISD/JGD products.

MMM Analysis Concept

MMM is a developed technology which is used to predict maintenance manpower requirements for a weapon system employed in a specific operational scenario. This prediction is accomplished through a simulation called the logistic composite model (LCOM). CHRT initiates MMM in the conceptual phase and supplements the LCOM simulation with the R&M model. (Czuchry, et al 1978)

The R&M model, like LCOM, is directly dependent on the MMM comparability analysis and maintenance action network description. These must still be provided through MMM, but much earlier than before and to the best degree of accuracy possible. The R&M model formats the comparability and maintenance action information in maintenance event matrices, and computes average demand on the maintenance system for an unconstrained maintenance environment. No attempt is made to account for peak work load saturations, queues of equipment awaiting repair, or other non-linear constraints. Average demand on the maintenance system over a period of flying hours is used to determine maintenance manpower requirements. The operational scenario is represented by flying hours, flying hours/sortie, maintenance shift length, shifts/day, and work days/week. Although the R&M model is a less precise method for predicting maintenance manpower requirements, it can be run more quickly and economically than LCOM.

During the conceptual phase some of the most significant decisions regarding design, operations, and support alternatives are made. These decisions can be made on the relative merits of the alternatives. Therefore the need is for a technique which is adequate for a relative merit consideration. The average demand derived data available through the R&M model is sufficient to provide this capability. Additionally, the nature of the model simplifies reiteration to evaluate alternatives. Although accurate absolute data might be preferable, the lack of accurate input data negates the added precision available through the LCOM simulation.

During the early validation phase, there are still many alternatives to consider and the lack of accurate input data remains. The R&M model is again applied in this time frame to aid in evaluating these alternatives. As the validation phase continues, the number of alternatives decrease and only serious contenders remain: Now is the time to apply LCOM and take advantage of its ability to more precisely simulate an operational weapon system and to more accurately predict maintenance manpower requirements. The R&M model is referred to as a screening device for LCOM during the early validation phase because it is used to ferret out non-viable alternatives.

During the full scale development phase, the LCOM simulation is the preferred means for estimating maintenance manpower requirements.

In addition to maintenance manpower requirements, the R&M model quantifies the $\overline{R}$ and $\overline{M}$ considerations required for the CHRT ISD/JGD analysis and the CHRT system ownership cost (SOC) model. The R&M model is required in all phases of acquisition to provide $\overline{R}$ and $\overline{M}$ data.

ISD/JGD Analysis Concept

In the conceptual and validation phases the analysis is used as an analytical tool to estimate the scope, magnitude, and cost of a coordinated ISD/JGD program. The ISD/JGD analysis has been developed specifically for CHRT. The goal of this analysis is to describe an efficient, economic, and unique mix of training and job guide documentation for any weapon system to which it is applied. A reiteration of this analysis allows investigation and evaluation of various ISD/JGD mixes and the effects of various alternatives on this mix. It must be recognized, however, that this concept as developed and described below is primarily applicable to the maintenance area. In larger weapon systems (B-52, C-5, C-141, Minuteman, Titan II) operations personnel perform maintenance type work. In-flight fault isolation, periodic tests of equipment, minor maintenance tasks, and even the methods/procedures for identifying and reporting discrepancies are all appropriate areas for considering the application of operations personnel and the use of job guides. Job guide documentation is also considered and suggested to assist in the accomplishment of certain operational tasks. It is assumed, however, that the primary means qualifying operator personnel will continue to be training.

Job guide development and instructional systems development consist of the procedures necessary to develop, maintain, and facilitate task performance and proficiency in a system. Both can be, and in the past often have been, developed more or less independently of each other. However, to be most effective both should be developed from a comprehensive knowledge of task requirements and with adequate consideration of each other. In addition, to be most effective both should be largely job/task oriented. Some of the benefits derived from an integrated job/task oriented approach to ISD/JGD are:

1. Reduced training time thus enabling personnel to be "operational" earlier
2. Use of lower aptitude and less skilled personnel
3. Increased maintenance effectiveness with implications for
   - reduced system failure rates
   - increased operational readiness
   - reduced spares consumption
4. Lower life cycle systems support cost.

The tool for achieving the desired integrated ISD/JGD mix is the task analysis. There are many common elements in the task analyses performed for both training and job guides. A systematic, integrated approach to the task analysis is essential to produce the most efficient mix of training and job guides, and to enable analyses of trade-offs between the two.

ISD Considerations

ISD is a systematic approach to developing a training program. The basic assumption is that a training program should provide only the need-to-know as opposed to nice-to-know information. With the present turnover rate of personnel, the cost of training, and a generally fixed enlistment period, need-to-know is generally considered task oriented because it increases on-the-job time by reducing training time. This approach does not preclude providing theory that is required to do the jobs, but it does imply that non-essential theory be eliminated from the training effort.

In CHRT, an initial assumption is that training, particularly for first-time enlistees, may be minimized by utilizing proceduralized JGD formats whenever feasible or warranted. It is further assumed that required training should be largely task-oriented. It is also recognized that few if any tasks can be fully supported by either job guides or training alone. Even with fully proceduralized aids some training will be required, and to the degree that deductive or proceduralized aids at various levels of detail are used, training requirements will be on the aids themselves. For example, one type of training that would be important when fully proceduralized aids are used is in the use of the aids themselves. This would include closely supervised instruction in locating sections in the aid and performing actual tasks with the use of the aid. Training of this nature would be carried out either on one subsystem within the group of subsystems on which a particular Air Force Specialty Code (AFSC) would be working or, if the subsystems were relatively heterogeneous, a selection of tasks across subsystems. This type of training is expensive on a per day basis because it requires a high instructor/student ratio and a high equipment/student ratio.

Coordinated with training would be hands-on instruction on using general testing equipment required in the specialty classifications and in using ordinary and special hand tools. Training of specific skills such as soldering, and training of special motor skills and perceptual judgements would also be required.

In order to estimate the duration and cost of this of hands on, task oriented training required to support the use of job guides, the following information is necessary:

1. Number of LRUs or shop replaceable units (SRU) (depending on whether the training is for line or shop maintenance).
2. Number of JGDs predicted to be associated with the LRUs and SRUs.
3. Degree of detail in the job guides.
4. Estimated instructor/student ratio.
5. Number and rate of students to be trained.
6. Number of actual equipments and simulators required.
7. Number and complexity of test equipments required of the specialty classification.
8. Number of special tools required of the specialty classification.
9. Number of and nature of special skills required.
10. Nature of training (e.g., formal course, field training detachment, on the job).

In addition to the hands-on, task-oriented training just described, there are certain kinds of information of a more general nature that should be imparted systematically in an information oriented training program. These include:

1. General description of the weapon system, its mission and characteristics.
2. Overview of the subsystems within the weapon system, their functions and interrelationships.
3. The layout or geography of the specific subsystems within the specialty classification being trained.
4. General overview of procedures and necessary forms and paperwork. (The specifics and practice in using forms, etc., would be included in the more task-oriented phase of training.)
5. General safety precautions.
6. General terminology and technical jargon associated with the specialty classification.
7. Career ladder information.
8. Anticipated working environment information.

The estimates of course duration and cost for this type of training would be based on an analysis of comparable courses with the same or similar topics (an associated training times) from previous training programs in similar systems.

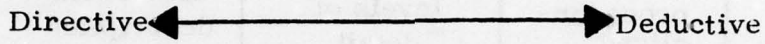
A basis, therefore, exists for estimating the training requirements for a weapon system during the conceptual and validation phases of system development. The estimates, though quite approximate, would serve as an input to predict some of the human resources impact of various design alternatives. During the validation phase these estimates would, of course, be significantly upgraded as the IRTA is further developed.

JGD Considerations

It is recognized that the present technical data procurement system neither allows for buying different formats for different subsystems nor for fully coordinating the development and completion of tech data and training programs. This does not make the traditional approach correct or economically advantageous. CHRT provides a process which suggests changes to the traditional methods. The range of technical documentation considered in CHRT is discussed in subsequent paragraphs.

In the CHRT methodology troubleshooting functions are defined as if they can be covered by essentially three basic formats ranging from fully proceduralized (directive) to system description with schematics (deductive). Thus there is:

Figure 3-1



FPJPAs	FOMM/SIMM or symptom cause charts	Schematics & system description

describes procedures

describes hardware

FPJPA - Fully Proceduralized Job Performance Aids

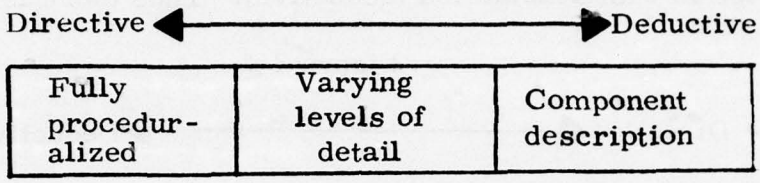
FOMM - Functionally Organized Maintenance Manual

SIMM - Symbolic Integrated Maintenance Manual

The fully-proceduralized format is characterized by high preparation costs, minimum training requirements, and early user performance capability. The fully-deductive format is characterized by being relatively less expensive to prepare, but requiring lengthy training periods in advance of and during job assignments.

For other maintenance functions such as remove and replace, the CHRT methodology considers three available formats:

Figure 3-2



One task of CHRT then becomes that of determining the most appropriate format or mix of formats for the job guide documentation taking a variety of conditions into consideration and relating them with the training implications.

While the initial baseline assumption in CHRT is that the system would be supported by job guide documentation, it is recognized that this is not always feasible or practical. For example, traditional job guide documentation lacks some types of information such as illustrated parts breakdown or hardware description frequently used for parts procurement and for basic texts in training programs. Job guides contain little theory to help personnel pass career development courses or job knowledge tests. To some extent, they provide inadequate support for the highly-skilled maintenance technician when he is called upon to repair multiple failures which occur too infrequently to be included in the manual.

Also, a fair amount of evidence indicates that experienced technicians resist the use of highly-proceduralized aids in that they reduce the challenge and meaningfulness of their work thus creating problems of worker satisfaction and motivation. There are also unanswered questions as to how much generalization of learning takes place with the use of proceduralized aids. On the other hand, the research data to date seems overwhelmingly encouraging as to the effectiveness of aids such as fully or partially proceduralized aids. What seems to be called for then is an attempt to determine an appropriate mix of aid formats to achieve optimum performance.

Since the development of complete training programs and job documentation is dependent upon detailed task analysis data, this development usually does not take place until the full scale development phase of the weapons system life cycle. Yet their role is so important in life cycle systems costing and in their potential effect on design option decision, that their impact must be evaluated in the conceptual stage of weapon system development. The CHRT provides an evaluation process by which this can be accomplished. The consolidation of the MMM/ISD/JGD approaches and an analysis of general task data supplemented by related training, tech data and personnel information allows one to: (a) project support requirements, (b) determine the most cost effective way to meet these requirements, and (c) describe a coordinated training and job guide program necessary to develop and maintain effective support of the system. The ISD/JGD analysis, therefore, should identify requirements which:

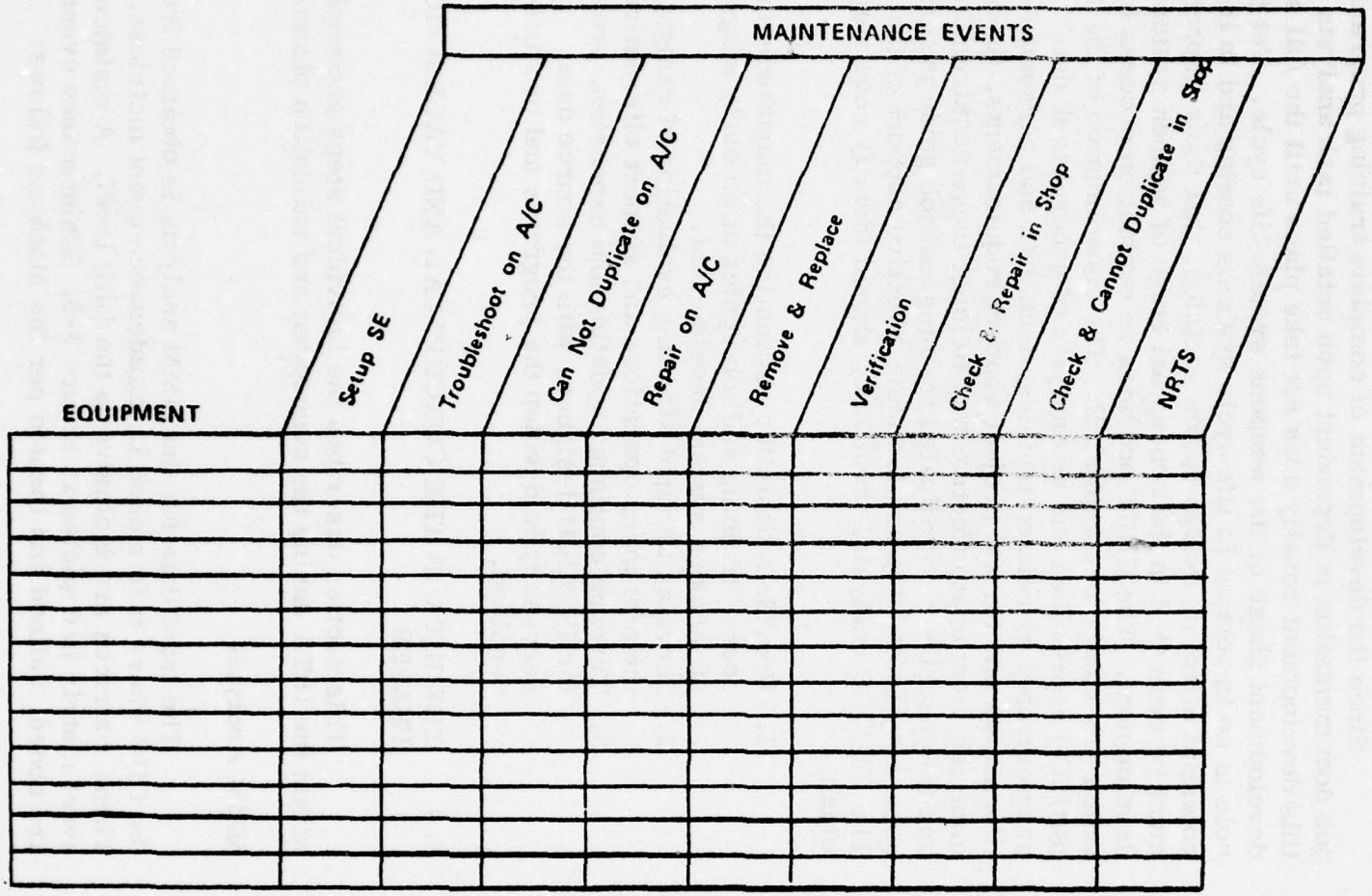
1. Provide a basis for estimating the magnitude and cost of training and job guides at an early stage of weapons system development.
2. Serve as an input affecting evaluation of design, maintenance, operations and support alternatives.
3. Through continued updating and expansion, provide the ISD/JGD designers with the source data necessary to develop the programs and products required.

3.4 THE IRTA IN THE CONCEPTUAL AND VALIDATION PHASES

This section describes the individual steps accomplished within the IRTA during the conceptual and validation phases.

MMM Analysis

The input data for the MMM analysis is obtained from the CDB where it is stored in maintenance event matrices. These matrices are inclusive to the LRU level. A maintenance event matrix is depicted in Figure 3-3. Maintenance events are coded, defined and located per the MMM as follows:



MAINTENANCE EVENT MATRIX
Figure 3-3

A -	set up support equipment	- Flight line
T -	troubleshoot on aircraft (A/C)	- Flight line
C -	cannot duplicate (CND) on A/C	- Flight line
M -	minor repair on A/C	- Flight line
R -	remove and replace (R&R)	- Flight line
V -	verification of R or M events	- Flight line
W -	bench check and repair	- Shop
K -	bench check and CND	- Shop
N -	not repairable this station (NRTS)	- Shop
H -	scheduled checks, inspections or service	- Flight line

Maintenance events are qualified and/or quantified in the matrices with respect to probability of occurrence, task time, AFSC and skill level required, maintenance crew size and necessary support equipment. Mathematical operations are performed on these data by the R&M model (Czuchry et al, 1978) which facilitates the determination of $\overline{R}$, $\overline{M}$ and maintenance manpower requirements on a system, subsystem or LRU basis.

A computerized version of a maintenance event presentation obtained as an output of the R&M model is shown in Figure 3-4. This presentation quantifies $\overline{M}$ for a UHF Radio (Equipment Code: AC 320 and its LRUs. $\overline{M}$ is described by mean time to repair (MTTR) and is shown by equipment and event. The rows depict terminating shop events, W; K; and N, by LRU or subsystem. The first seven columns, left to right, indicate the flight line maintenance events. The eighth and ninth columns show shop activity (related to W, K, and N) and totals, respectively. Totals are also shown for each row and column.

A review of Figure 3-4 indicates a relatively high bench check and repair time for the receiver-transmitter (RxTx), LRU number: AC321. This would indicate that it may be a high driver, (i.e., create excessive demand for human resources). Consideration of this information should then result in acceptance of the predicted bench check and repair time or substitution with an alternative radio. The CHRT process would then be reiterated to evaluate the effect of any alternative chosen.

MTTR BY TASK PER LRU

SUBSYSTEM– AC320

		AGE F/L	TS F/L	R&R	VR&R	CND A/C	M A/C	VM A/C	SHOP	TOT/OUT
LRU– AC321 (RXTX)										
	W	0.13582	0.13582	0.95074	0.33955				3.39550	4.95743
	K	0.00590	0.00590	0.04130	0.01475				0.04130	0.10915
	N	0.00590	0.00590	0.04130	0.01475				0.03835	0.10620
	Sub	0.14762	0.14762	1.03334	0.36905				3.47515	5.17270
LRU– AC322										
	W	0.00104	0.00104	0.00728	0.00260				0.00416	0.01612
	K	0.	0.	0.	0.				0.	0.
	N	0.00104	0.00104	0.00728	0.00260				0.00520	0.01716
	Sub	0.00208	0.00208	0.01456	0.00520				0.00936	0.03328
LRU– AC323										
	W	0.00154	0.00154	0.01078	0.00386				0.04543	0.06314
	K	0.	0.	0.	0.				0.	0.
	N	0.00018	0.00018	0.00126	0.00045				0.00063	0.00270
	Sub	0.00172	0.00172	0.01204	0.00430				0.04606	0.06584
	CND	0.02600				0.10400				0.13000
	M	0.02262	0.02262				0.12441	0.05655		0.22620
TOT/TSK		0.20004	0.17404	1.05994	0.37855	0.10400	0.12441	0.05655	3.53057	5.62810

HIGH SHOP MTTR
W = BENCH CHECK & REPAIRS

MAINTENANCE EVENT MATRIX
(Computerized Version)

Figure 3-4

The R&M model is used throughout the conceptual phase for all CHRT iterations and continues to be used during the early validation phase to screen out non-viable alternatives. LCOM is initiated during the validation phase on the remaining viable alternatives to establish firm maintenance manpower requirements based on a complete operational scenario.

The outputs of the MMM analysis, $\overline{R}$; $\overline{M}$; and maintenance manpower requirements:

- quantify a portion of the human resource impact of an alternative
- provide input to the SOC model
- are used in the next step within the IRTA, the ISD/JGD analysis.

ISD/JGD Analysis for Maintenance

During the conceptual phase, the ISD/JGD analysis requires a number of inputs. These are used to develop estimates of the various ISD/JGD formats and requirements for the basic system configuration and alternatives. Data inputs are obtained from the maintenance event matrices, the maintenance activity matrices, task/condition matrices, maintenance manpower requirements and personnel availability matrices. The first three inputs are reviewed and a task intensity profile is developed from them. This profile provides the initial basis for estimating the magnitude of various proceduralized formats and the content of manuals and training. Also included in this estimation effort is a consideration of the remaining two inputs, maintenance manpower requirements and the personnel availability matrices.

During the validation phase, the information mentioned previously will be updated, and design, maintenance, operations and support alternatives will be evaluated for their effect on ISD/JGD requirements. The ISD/JGD analysis will then be supplemented by data from available engineering documentation, schematics, and interviews with engineers and maintenance personnel, and analyses of prototypes of breadboard models of the actual equipment. The output of the validation phase will be a general upgrading of estimates made during the conceptual phase. Specifications for both job guides and training, for inclusion in requests for proposal, may also be developed from these estimates.

In both phases, this knowledge regarding training and tech data is extremely important because it is still early enough in the system life cycle to change design or policy. Therefore, if the ISD/JGD impact is not acceptable, appropriate alternatives may be considered to achieve more effectiveness at less cost.

The subsequent paragraphs describe the data inputs required for the ISD/JGD analysis

Maintenance Event Matrix

Maintenance event data is the same as that previously described in Figures 3-3 and 3-4. This, plus maintenance activity data, provide the general task information required for the ISD/JGD analysis.

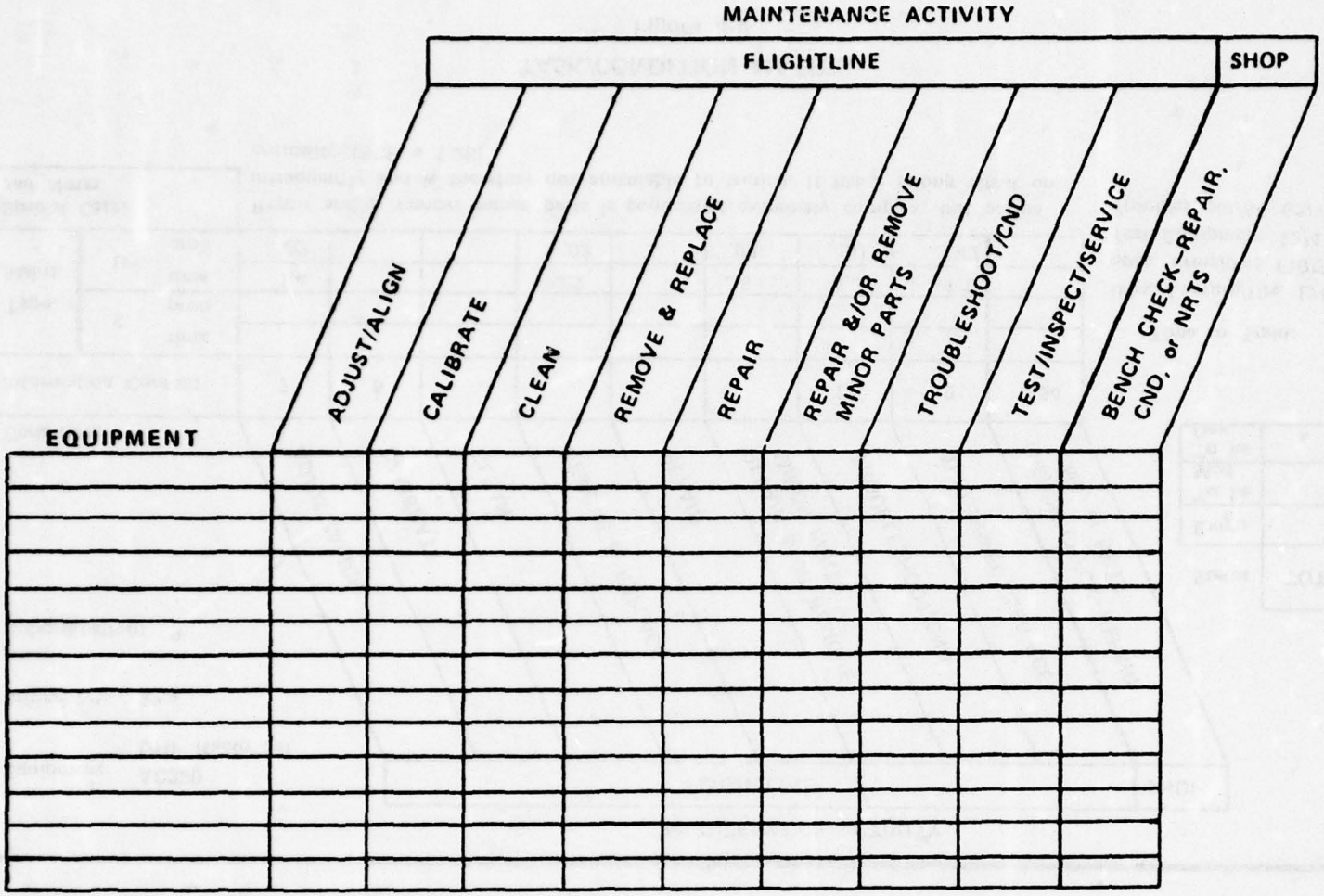
Maintenance Activity Matrix

Maintenance activity data is drawn from the CDB where it is stored in the maintenance activity matrices. A maintenance activity matrix is shown in Figure 3-5. This data is derived directly from the AFLC D056 data system; run D056B5504, Detail Shop Actions for Selected Work Unit Codes; "how malfunctioned" data. The specific information of interest is an eleven month summary of maintenance actions taken, the number of occurrences each, and hours per action on each subsystem and LRU. The subsystems and LRUs selected are the same used to develop the maintenance event data. For convenience and compatability with MMM data, similar maintenance actions (this term is defined in any -06 Work Unit Code Manual) are grouped under the same maintenance activities identified in the maintenance activity matrix.

Task/Condition Matrix

The task/condition matrix provides six categories of information for each piece of equipment for use in projecting ISD/JGD requirements. This matrix completed for the UHF radio is shown in Figure 3-6. The six categories are type maintenance, time to train, information content, ISD/JGD status, criticality, and subordination.

Type maintenance includes the time (in hours) and the probability of occurrence for both scheduled (S) and unscheduled (U) type maintenance. This information is presented for each maintenance activity to allow subjective judgements regarding behaviors. The data is obtained from the maintenance activity matrix.



MAINTENANCE ACTIVITY MATRIX

Figure 3-5

Equipment: AC320 UHF Radio Set

Criticality: 33.4

Subordination: 3

Conditions:

			MAINTENANCE ACTIVITY: FLIGHTLINE								SHOP
			ADJUST/ALIGN	CALIBRATE	CLEAN	REMOVE & REPLACE	REPAIR	REPAIR &/OR REMOVE MINOR PARTS	TROUBLESHOOT/CND	TEST/INSPECT/SERVICE	BENCH CHECK-REPAIR, CND, or NRTS
Information Content			7	5					17	9	124
Type Maint.	S	time									
		prob.									
	U	time	1.4			1.1		2.6	4.0	1.1	
		prob.	.02			.03		.02	.51	.42	

Status	TOT	TOM
Exists		
To be Mod.		
To be Dev.	x	x

Special Cases and Notes

Repair and/or remove minor parts is considered extremely complex, but occurs infrequently and is therefore not ameniable to trining. It has a strong effect on criticality (SCF = 1.25)

Time to Train:

(Hrs. Lecture/Hrs. Lab)
Spec. Principles 110/32
Test Equipment 12/4
Troubleshoot/SE 62/18

TASK/CONDITION MATRIX

Figure 3-6

Time to train is used to estimate course length, content, and cost. Time-to-train is obtained from existing course data and is measured in terms of the lecture/lab hours spent in the task-oriented training in this case, of the 32860 technician. These times are obtained by first coding the segments in the current Avionics Communication Specialist Course (3ABR32830) according to the descriptions shown in Figure 3-7 and then accepting only the B.3, C.3, D.1 and D.2-coded segments as being task-oriented.

A similar approach to estimating the amount, content, and cost of manuals uses the information content entries for each maintenance activity. These entries indicate the number of pages devoted in current manuals to the various activities and consequently can serve as one of the factors in estimating characteristics of the JGD products.

The ISD/JGD status is also indicated in the matrix in terms of whether they (a) already exist in the task-oriented form, (b) need only to be modified using existing manuals and task analyses, or (c) must be completely developed.

The criticality factor in the early phases of systems development is probably best indicated by the impact on operational readiness and the cost implications of resources consumed. Readiness is a function of both the probable flight hours between maintenance actions and the probable time spent in flightline maintenance before the weapon system is returned to a ready-for-operation condition. A suitable measure of resources consumed is the ratio of maintenance manhours per flight hour. For the UHF radio the criticality is equal to 33.4, a number to be compared with that of other systems.

The formula is expressed as follows:

$$\text{Criticality} = \frac{\text{MFHBMA}}{\text{MFHBMA} + \text{MTTR}_F} \bullet \frac{1}{\text{MMH/FH}}$$

where

MFHBMA - Mean Flight Hours Between Maintenance Activity
MTTR_F - Mean Time to Repair (Flightline)
MMH/FH - Maintenance Man Hours/Flying Hour

A. BASIC PRINCIPLES
1. DIRECT CURRENT CIRCUITS (CKTS.)
2. ALTERNATING CURRENT CKTS.
3. RLC CIRCUITS
4. SOLID STATE PRINCIPLES
5. SOLID STATE WAVE GENERATING & WAVE SHAPING CIRCUITS
6. DIGITAL TECHNIQUES
7. PRINCIPLES & APPLICATIONS OF ELECTRON TUBES
8. TRANSMIT & RECEIVE SYSTEMS
9. MICROWAVE DEVICES & SOLDERING

B. GENERAL INFORMATION, FUNDAMENTALS, & ADMINISTRATIVE
1. GENERAL
- ORIENTATION
- SAFETY
- SECURITY
- MAINTENANCE POLICY
- TOOLS
- AIRCRAFT FAMILIARIZATION

2. TECHNICAL PUBLICATIONS, PAPERWORK
- MAINTENANCE MANAGEMENT
- DATA COLLECTION
- T.O.s
- SUPPLY

3. MAINTENANCE PROCEDURES
a. ORGANIZATIONAL
b. INTERMEDIATE

C. APPLIED PRINCIPLES
1. GENERAL
- INTRODUCTION
- LOGIC, SYMBOLS
- PRINCIPLES (general characteristics)
- APPLICATIONS, GENERIC EQUIPMENT

2. SPECIFIC
- UTILIZATION
- PRINCIPLES, SPECIFIC EQUIPMENT
- PERFORMANCE, SPECIFIC EQUIPMENT

3. TEST EQUIPMENT
- CHARACTERISTICS
- GENERAL USAGE

D. EQUIPMENT RELATED FEATURES
1. SUBSYSTEM/LRU
- BLOCK DIAGRAM
- SYSTEM ANALYSIS
- COMPARISON OF LRUs
- PURPOSE/DESCRIPTION
- SUBSYSTEM FUNCTIONS
- OPERATION

2. LRU/COMPONENT
- LRU DESCRIPTIONS
- BLOCK DIAGRAM OF CIRCUITS
- SCHEMATICS
- WIRING DIAGRAM
- DETAILED ANALYSIS
- CIRCUIT ANALYSIS

E. MAINTENANCE REQUIREMENTS & EQUIPMENT PERFORMANCE
1. STANDARDS, CHECKS, ADJUSTMENTS
2. TROUBLESHOOTING PROCEDURES/SUPPORT EQUIPMENT

COURSE SEGMENT DESCRIPTORS

Figure 3-7

Subordination, the number of components that could be causing the malfunction or that have to be serviced, is a reasonable indicator of difficulty. Proceduralized aids should be considered if subordination is great, especially in troubleshooting. Since there are three LRUs in the UHF radio, the subordination value is 3 for this system.

Task Intensity Profile

All the tasks associated with the weapon system need to be analyzed in a general sense during the early weapon system acquisition process. Task intensity, which considers the entire set of tasks performed on a specific equipment, is suggested as an indicator of the composite task requirement.

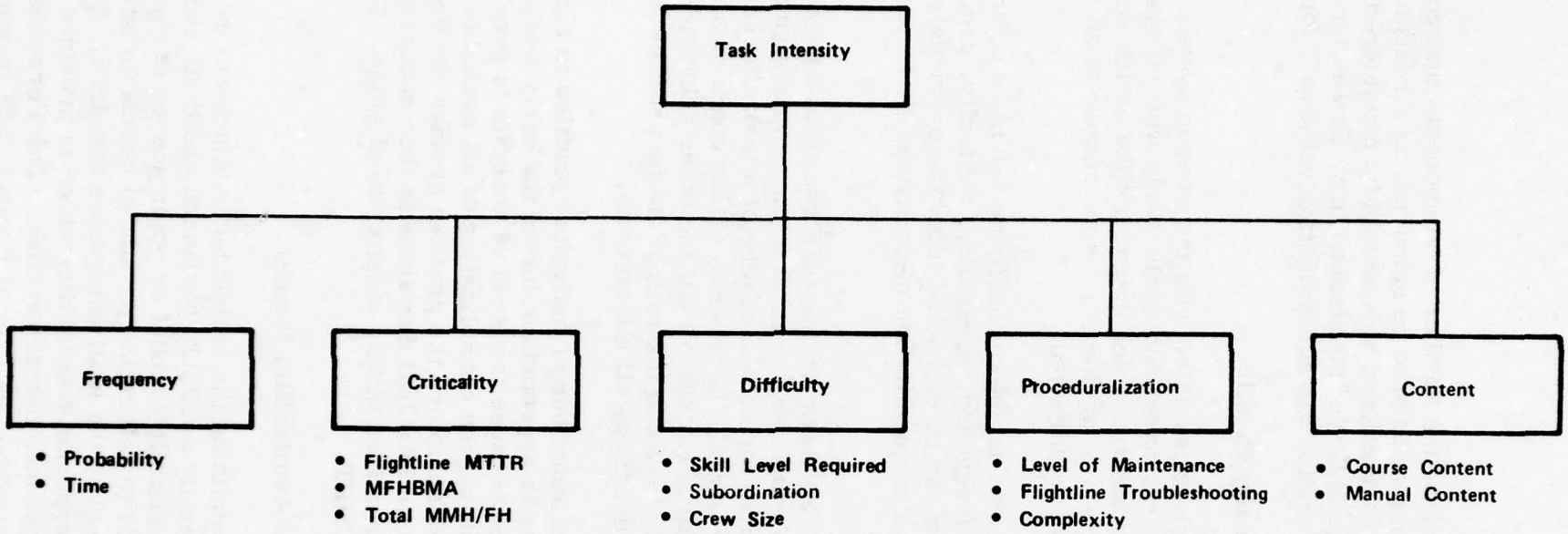
This indicator is shown in Figure 3-8 to be a function of the characteristics: frequency, criticality, difficulty, proceduralization, and content. Data can be extracted from the previously generated matrices to arrive at quantitative measures of these task characteristics.

Quantitative values for the UHF radio have been entered into the first row in Figure 3-9. A profile based on assigned ratings between one and five for each measure of a task characteristic is also shown in the figure. In order to obtain more meaningful profiles, quantitative ratings for all the other subsystems should be obtained. Only then can the ratings in the profiles be assigned on a relative basis across all subsystems.

The use of a number of individual profiles to characterize the task requirements is appropriate during the early weapon system acquisition phases because the level of analysis is general and not detailed. By avoiding the consolidation of all available task data in a single general descriptor, the profiles provide the opportunity to initiate and evaluate ISD/JGD decisions in the conceptual phase and to substitute alternatives at this most critical stage. This was not possible before CHRT.

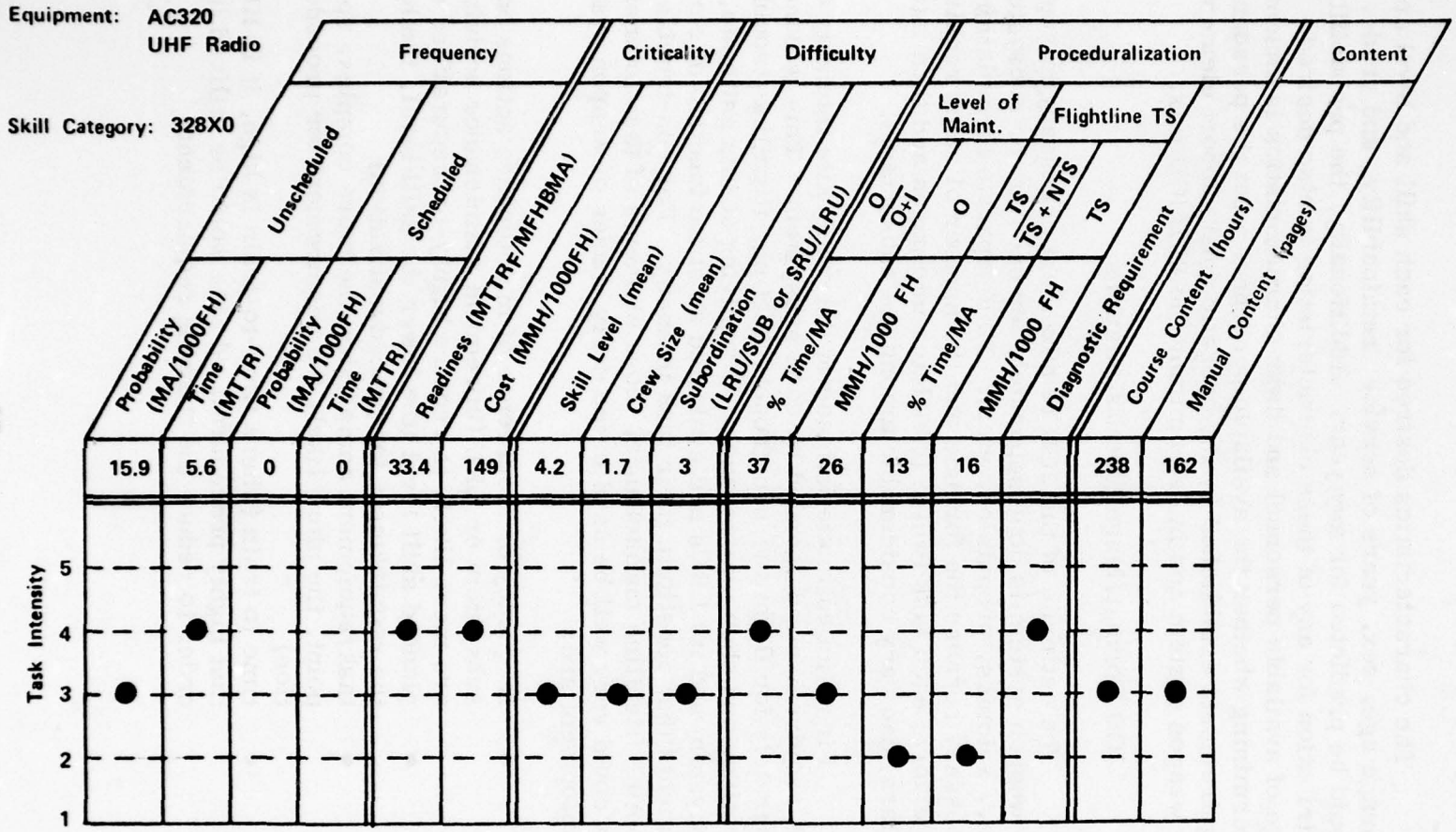
Personnel Availability Matrix

Upon determining the maintenance manpower requirements, one must then identify available personnel and their characteristics. The personnel availability model or other source of similar data must be exercised to determine personnel characteristics of available personnel in the skill categories required. This results in a prediction of personnel availability which is provided in a matrix of skills versus personnel characteristics. The Personnel Availability Model is being developed as part of Project 1959 in work unit 03.



COMPOSITE TASK REQUIREMENTS

Figure 3-8



TASK INTENSITY PROFILE

Figure 3-9

The characteristics desired for each skill and level are average age, sex, years of service, retainability, and grade. This should be predicted for any year. Additionally, the probability distribution for any of these characteristics is also desired. Knowledge of available personnel and their characteristics is essential in determining whether the available personnel meet the personnel requirements established by the operation and support elements of the weapon system and in determining the ISD/JGD mix.

JGD Format/Magnitude Estimations

The estimate of the JGD requirement necessary to support the weapon system is done separately for each major subsystem (i.e., avionics, propulsion, etc.). This separate formulation is necessary because the formats and the number of steps required to perform each task (which translates into pages and then into dollars) can vary considerable among the subsystems.

First, an estimate is made of the composite intensity of the task requirements demanded by each subsystem. This is done separately for flightline/non-troubleshooting, flightline/troubleshooting, and shop maintenance. In arriving at this estimate, each subsystem and its LRUs are evaluated as some function of certain elements that constitute their task intensity. For non-troubleshooting flightline maintenance, those elements of task intensity that could very well be used in the early phases of weapon system development are:

- frequency of occurrence of maintenance actions on the subsystem or LRU (infrequent maintenance activities are more likely to require highly-proceduralized aids)
- planned skill level (the lower the skill level, the higher the requirement for proceduralization)
- task/equipment complexity (the more complex, up to a point, the more likely the requirement for proceduralization)
- time to train (where time-to-train is high, it is likely that highly proceduralized aids would be utilized in order to reduce the training requirement)

This data is available from the task intensity profile. The predicted format (degree of proceduralization) required for each major subsystem would be estimated by combining profile ratings and any special case factors for each piece of equipment according to the above criteria. A tentative equation for the non-troubleshooting flight line JGD format has been developed as part of this study and is as follows:

$$\text{Format Rating} = 1/4\ [(6-R_F) + (6-R_S) + R_C + R_T] \bullet SCF$$

where the following factors are of prime consideration.

R_F = Frequency Rating (use MA/1000FH + MTTR)•1/2
R_S = Skill Rating
R_C = Complexity Rating
R_T = Time to Train Rating (i.e., Course Content)
SCF = Special Case Factor (see Task/Condition Matrix)

The 6's appear in the equation because of the inverse relationship between the R_F and R_S ratings and the format. Continuing with the example, the values of the ratings in Figure 3-9 and the special case factor in Figure 3-6 are inserted into the format equation as follows:

$$\text{Format Rating} = 1/4\ [(6-2.5) + (6-3) + (4) + (3)] \bullet 1.25 = 3.13$$

where

$R_F = (3 + 4) \bullet 1/2 = 3.5$
$R_S = 3$
$R_C = 4$
$R_T = 3$

This format rating of 3.13 implies that JGD for the example is just slightly above average for all subsystems. One might consider therefore some redesign to reduce task complexity or more detailed job guide coverage to assure proper performance.

Equations for both non-troubleshooting and troubleshooting format will be further developed and refined during the Phase II demonstration.

An examination of the task/condition matrix shows that there are essentially three non-troubleshooting activities carried out on this piece of equipment: adjust/align, remove & replace, and test/inspect/service. The mean time for these activities is not very high and, with the exception of test/inspect/service, they occur infrequently. The higher frequency for test/inspect/service indicates that more deductive type aids are called for in this activity along with a higher degree of training. The other activities, because of their infrequent occurrence, suggest high proceduralization. Consequently, there are a number of potential trade-offs, with CHRT indicating which are the most promising.

The format rating for all equipments within the weapon system is then determined. This value is further modified by information which is available on a systems level. Examples of these are personnel turnover and span of supervision. Thus, if personnel turnover were high, the estimate of required proceduralization would be increased, and if span of supervision were high, the estimate of proceduralization would be increased.

The format rating can be used to estimate JGD costs (e.g., the greater the degree of actual, the greater the amount of analysis required). As CHRT is first applied, the dollar costs associated with various format values is at best tenuous, however, further experience with CHRT augmented by auxiliary data, should improve the cost to value relationships. Furthermore, the SOC equations for the manuals will take into account the cost factor variation due to degree of detail.

ISD Format/Content Estimates

During the conceptual phase, estimates or predictions concerning training are greatly influenced by estimates of JGD. For example, the format and content of training will be quite different for systems supported by fully-proceduralized aids as opposed to those supported by standard TOs. It has been demonstrated that the use of FPJPAs can result in a reduction of training time by as much as 50 percent. However, the cost of this highly task-oriented training may be as high or higher depending on such factors as lower student/teacher ratios, the use of prime equipment or sophisticated simulators as training equipment, etc.

Probably the best estimate that presently can be made at this stage of the CHRT development is as follows:

Taking present course length and associated costs:

- if fully proceduralized JPAs are to be used, reduce course length estimates by 40%.
- if less detailed job guide documentation is to be used. reduce course length estimates by 15%.
- if deductive aids are to be used, course length stays the same.

Naturally these estimates will also be influenced by other factors, especially projected personnel skill levels. Also, to the above estimates must be added a constant to include basic types of training all airmen could receive regardless of the type of system they would be maintaining.

Continuing with the example, the task intensity profile shows that present course length related to this equipment is 238 hours. Since the above analysis suggests a mix of JGD formats leaning toward the partially to fully proceduralized formats, an initial estimate might be that the course length could be reduced by 20 percent, or 48 hours.

As emphasized, the decision as to the appropriate mix of job guide documentation and training cannot be made from a single piece of equipment. All equipment within the subsystems must be analyzed and an appropriate judgement made. Judgements must also be made regarding the scope, type and quantity of training media and the techniques employed for performance measurement.

ISD/JGD Analysis for Operations

The ISD/JGD analysis for operations is a much simpler and more judgemental process than that for maintenance. First of all, it is in fact an estimate of the scope and magnitude of ISD. Although job guides will be considered as supporting material, the scope and magnitude of the JGD effort should not be significant. Secondly, in operations one deals with a more or less standard skill level and only a few AFSCs.

The data used to determine the ISD requirement is drawn from the CDB. It consists of an operations task list, task/condition data, operations manpower requirements and personnel availability data.

Operations Task List

Operations task data is provided in a listing. It includes basic operations tasks for each operator function and unique operations tasks peculiar to the specific weapon system. In the Advanced Medium STOL Transport (AMST), for instance, STOL landings and takeoffs are unique tasks. Additionally, this list will also note those maintenance tasks which will be performed by the operator.

Task/Condition Data

Task/condition data for operations is also drawn from the CDB but is presented in a listing rather than a matrix. It consists of training and training related resource data for a similar system (e.g., for the AMST, C-130 data would be provided). It would also list any operations or training limitations, such as restricted flying time, which would indicate a need for simulators, crew procedures trainers, etc.

Operations Manpower Requirements

Operations Manpower Requirements data drawn from the CDB is provided in terms of skills and quantity of personnel. Like maintenance manpower requirements, this data reflects a direct human resource impact and is also used for obtaining SOC estimates.

Personnel Availability Data

Personnel availability data is presented in a matrix similar to that for maintenance and drawn from the CDB. For operations, however, the emphasis is on retention and turnover in order to size the training course throughout system life cycle.

ISD Format/Content Estimation

The information discussed previously will be reviewed by experienced personnel who will provide an ISD estimate based on comparability to the system being procured and the ISD/JGD approaches considered. The ISD estimate is described in terms of course length, number of instructors and students per course, course cycles per year, media and media time, class time and flying training time. Where standards for determining these facts are available and appropriate, they will be used.

3.5 THE IRTA IN THE FULL SCALE DEVELOPMENT PHASE

The IRTA in the full scale development phase is similar in concept to that performed during the conceptual and validation phases but expanded in scope and detail. In addition to the MMM analysis and the ISD/JGD analysis for maintenance and operations, there is also a general task analysis and a detailed task analysis. The general task analysis for maintenance rather than the MMM comparability analysis provides the input to the MMM analysis and the ISD/JGD analysis for operations. A detailed task analysis is performed for both maintenance and operations. It provides the basis for a coordinated instructional system and job guide program. Figure 1-2 on page 1-3 should be reviewed to place these analyses in the proper perspective.

General Task Analysis

The CDB is updated early in the full scale development phase with current information which directly reflects the equipment being procured. This current information is used to derive on-equipment data, specifically: a current equipment listing and configuration; verified or proposed equipment performance parameters (e.g., $\overline{R}$, $\overline{M}$); and implemented maintenance and support approaches. This information is required to the LRU level in order to adequately support the MMM analysis.

For maintenance, the general task analysis draws heavily on the initial steps of maintenance task analysis described in AFHRL-TR-73-43(II). A task identification matrix, as described in that report, is constructed. Initially, an analysis to the LRU level sufficient to satisfy the MMM maintenance action network criteris is accomplished. The analysis is then expanded to the lowest functional component, and ultimately results in a complete comprehension of equipment: its purpose; configuration and location; theory of operation; displays and cues; operational and maintenance procedures; and failure mode. The scope of the work to be accomplished is determined and described, and the tasks annotated into the skills and knowledge requirements. Task complexity, criticality, newness, time and frequency, safety, and most likely malfunction are also determined.

A general task analysis is also performed on operations. Both the maintenance team and the operations crew are required to know about the hardware, the operational functions, and the systems/subsystems interaction. The distinction between their on-the-job

requirements tends to be along the dimension of required skill and knowledge about the hardware. The maintenance man, for instance, is primarily interested in maintaining or returning subsystems to within tolerance conditions. He operates directly upon the hardware which the operations crewmember is required to control. The operations crew is required to check on the integrity of the equipment, and to operate it successfully in designated missions. The operations crew may also be required to perform in-flight/on-duty inspection and checks, minor maintenance, fault detection and isolation, and fault reporting. Since the two groups, generally, perform different type tasks, they have different needs for training and information. While maintenance proficiency is attained by a judicious mix of training and job guide documentation, operator proficiency comes primarily from training. For flight crew members, in particular, the training is of a transitional nature. That is, the purpose is not to teach basic operational skills, but to teach and practice the application of already acquired basic operational skills in the operation of new equipment.

This emphasizes a critical point. The entry skills and knowledges of the user, both maintenance personnel and operators, must be assessed. This is especially important in determining what is to be trained.

During the conduct of the general task analysis, the necessary products are developed. An example of these products for maintenance procedures would be such items as the preliminary task identification matrix (PTIM), ATIM, level of detail guide, test equipment and tool use form, generalized task list, detailed step description worksheet, etc.

General Task Analysis for Maintenace

The basic steps in the general task analysis for maintenance are stated below:

1. Prepare a task identification matrix
   a. Equipment by maintenance function (e.g., adjust, align)
   b. Conditions under which tasks are performed
   c. AFSC level performing task
   d. Tools and support equipments required
2. Estimate criticality, difficulty, and frequency of task
3. Identify skills and knowledges required for task
4. Compare with skills and knowledges available.

General Task Analysis for Operations

The basic steps in the general task analysis for operations are stated below:

1. Identify operations task
2. Perform task identification by AFSC
   a. AFSC performing task
      (1) Interaction among crew required
      (2) Ancillary maintenance tasks
   b. Equipments involved
   c. Conditions under which tasks are performed
3. Estimate criticality, difficulty, frequency, and time constraints for tasks
4. Identify skills and knowledges required for tasks
5. Compare with skills and knowledges available.

MMM Analysis

The general task data required to support MMM is formatted both as maintenance action networks and maintenance event matrices. The R&M model continues to be used for determining $\overline{R}$, $\overline{M}$, and gross maintenance manpower, and is especially useful with the impact analysis. The LCOM simulation, however, becomes a very powerful tool during full scale development since alternatives are limited, significant on-equipment data is available, and the operations scenario is more realistic. The major output at this time is the estimate of maintenance manpower requirements.

ISD/JGD Analysis

The next step in the IRTA is the ISD/JGD analysis for both maintenance and operations, although it is assumed that operator performance will be primarily supported by training. With general task data, manpower requirements, task/condition data and personnel availability characteristics in hand, the decision can be made as to what tasks are to be covered by ISD and what tasks are to be covered by JGD. The ISD/JGD scope and magnitude can then be estimated. The decision will be made in the manner recommended by AFHRL-TR-73-43(II), and the estimation of scope and magnitude in the manner previously recommended for the conceptual and validation phase.

Detailed Task Analysis

The detailed task analysis, particularly for maintenance, is an analysis conducted on the actual equipment or prototype by teams of experienced personnel.

Maintenance tasks are broken down into steps with cues and responses delineated, and hazards, failure modes, fault isolation, and the like identified. For operations, a functional analysis is conducted using techniques such as operational sequence diagrams. Cues, actions, criteria, feedback are determined. Thus the nature of the analysis may vary somewhat depending on whether it is for maintenance or operations.

At the time the detailed task analysis is undertaken, the JGD/ISD trade-off will have been accomplished. The detailed task analysis, therefore, will differ in certain respects depending upon whether the analysis is leading to job guides or to training. The difference, however, is primarily one of emphasis, as similar items of task information are needed for both efforts.

Detailed Task Analysis for Maintenance

The basic steps in the detailed task analysis for maintenance are stated as follows:

A. Maintenance tasks: non-troubleshooting and proceduralized portions of troubleshooting
   1. Break down tasks into subtasks and steps (elements)
   2. Identify and describe cues and responses for each step
   3. Identify hazards and special conditions

B. Maintenance tasks: non-proceduralized troubleshooting
   1. Perform a functional analysis
      a. Prepare logic trees
      b. Prepare fault isolation charts
      c. Perform failure mode analysis
      d. Collect malfunction data
   2. Determine troubleshooting strategy
   3. Identify hazards and special conditions.

Detailed Task Analysis for Operations

The basic steps in the detailed task analysis for operations are stated as follows:

1. Breakdown tasks into steps
2. Perform a functional analysis
   a. Operational sequence diagrams
      (1) Determine operator decision
      (2) Control operations (actions)
      (3) Information transfer
3. Identify cues and detailed responses
   a. Establish performance criteria
   b. Identify feedback
4. Prepare time lines for above
5. Describe task activities
6. Perform training analysis.

Section 4
PRODUCT DEVELOPMENT

4.1 OVERVIEW

Instructional system and job guide product development is the coordinated and evolutionary development of the training and tech data programs. The definition of the mix of these two products is the goal of the CHRT integrated requirements and task analysis. This is the ISD/JGD trade-off. The results of the IRTA initially are used to determine the balance of this ISD/JGD trade-off or, as it is termed in CHRT, the ISD/JGD mix and eventually to develop the products. While task-oriented products are the goals of this effort, this approach does not preclude the continuation, use, or development of traditional training or documentation where they are suitable.

The ISD/JGD product development describes the training, tech data, and personnel elements of the integrated logistic support program, and extends from the conceptual phase through the production/deployment phase. The specific products are the ISD/JGD concept, plan, and program. The personnel requirements are derived directly from the MMM analysis and the operations manpower requirements determination.

The success of the ISD/JGD effort depends totally upon the extent of coordination among those agencies responsible for the individual products. In order to formally implement this integrated approach to ISD/JGD, therefore, formal direction and instructions must be provided within the USAF.

4.2 THE ISD/JGD CONCEPT

The initial ISD/JGD products are the training and tech data concepts. These documents as developed through CHRT will reflect a coordinated approach to training and technical data. Additionally, the personnel portion of the training concept will reflect the manpower requirements derived through CHRT. All this data results from the initial IRTA in the conceptual phase.

4.3 THE ISD/JGD PLAN

A further qualification and quantification of the ISD/JGD mix is determined during the validation phase. This is reflected in the training and tech data plans. These plans then reflect the coordinated approach to training and tech data. The personnel portion of the training plan reflects CHRT manpower requirements. These plans are the final output of the series of many trade-off studies that take place in the validation phase. They provide the basis for direction given to the full scale development phase contractor regarding the full scale development training and tech data program.

4.4 THE ISD/JDG PROGRAM

The ISD/JGD program is the result of a fully coordinated ISD/JGD effort. Present specifications for job guide and training development, with some minor modifications, would continue to be used in the full scale development effort with one major change. The major change would be direction dictating and describing the coordination of the manuals and training development effort.

The application of instructional system development principles and processes for the development and accomplishment of education and training programs throughout the United States Air Force is directed by AFM 50-2. Guidance for the application of ISD is provided in AFP 50-58. Guidance for JPA development is provided in such documents as MIL-J-83302, MIL-M-38800A, and MIL-M-83495.

During full scale development, the job guides will be produced in draft form, validated, verified, updated, and produced in final format. Training programs will also be developed and validated along with media and performance measuring instruments. The aim with respect to training would be to minimize the amount of formal training required and have a greater emphasis on on-the-job training and programmed instruction.

4.5 COST ESTIMATION

Suitable formulas for ISD and JGD will be developed as experience with CHRT increases. For example, a formula which describes the JGD magnitude by number and type of page (i.e., troubleshooting or non-troubleshooting procedure, schematics, pictorials, etc.) is considered appropriate for estimating JGD cost since cost/page data is available from existing literature. The general format and the factors to be considered by a JGD formula are as follows.

Non-Troubleshooting Content = $K_1 \bullet N_u \bullet N_a + C_1$

where:

K_1 = combination of terms, such as:
- format (i.e., fully proceduralized, partially proceduralized, deductive)
- average number of steps per action
- average number of steps per page
- average amount of narrative text per action
- average number of graphic/pictorials per action

N_u = number of units = LRUs, functional units, or piece parts

N_a = number of activities = remove, replace, calibrate, etc.

C_1 = pages of general information in non-troubleshooting section

Troubleshooting Content = $K2 \bullet N_L + C_2$

where:

N_L = number of LRUs/SRUs

$K2$ = combination of terms such as:
- format (fully proceduralized, partially proceduralized, simple logic block diagram, and schematics)
- average number of steps per page
- average amount of narrative text per subordinate unit
- average number of schematics/diagrams per subordinate unit
- average number of troubleshooting steps per LRU (assumed value = 2)

C_2 = pages of general information troubleshooting section

The above procedure was applied to the UHF radio as an example to estimate the cost of a non-troubleshooting job guide. Cost figures can then be applied to the above terms, e.g., so much per step; so much per diagram, schematic, exploded view, etc. The results of the analysis are as shown:

For the UHF radio (AC 320), there are:

- 3 LRUs
- 7 actions per LRU (adjust, align, remove, replace, test, inspect, and service)
- 3 units x 7 actions = 21 actions
- 21 x 25 steps = 525 steps
- $\frac{525 \text{ steps}}{10 \text{ step/page}}$ = 52.5 pages (53 pages)
- instruction cost = $20 x 53 pages = $1060
- pictorial cost = $100/page x 53 = $5300
- total cost = $6360 + [$C_2$ • (cost per page of C_2)]

The following assumptions were made:

- Each action averages 25 steps
- Each page contains ten steps
- Average cost of proceduralized instruction is $20 per page. This covers instruction steps only
- Pictorials to support a page of instruction average two line drawings. This cost estimate is $100 per page of instruction.

As the Phase II demonstration proceeds, suitable formulas will be developed, refined, and validated for both ISD and JGD. The formulas will be appropriate to the full range of ISD and JGD programs.

Section 5
THE IMPACT ANALYSIS

5.1 OVERVIEW

The impact analysis is that unique activity of the CHRT methodology described in AFHRL-TR-78-6(I) which allows one to consider design, maintenance, operations, and support alternatives and determine their impact on human resources and cost. The need for alternative considerations may arise either as the result of a review of the existing design which has identified high human resources and system ownership cost drivers at a design decision, or to determine the effect of various policy alternatives upon a specific design. CHRT, through the impact analysis, provides a means to relate human resources and system ownership cost to design, maintenance, operations, and support. Additionally, it provides this capability early enough to allow engineering, maintenance, operations, and logistic personnel to incorporate the results in the basic and key decisions during the inital stages of system acquisition.

5.2 THE IMPACT ANALYSIS

As mentioned previously, data is retained in the CDB on a reference system, a baseline system, and a current system. The impact analysis is always accomplished on the current system. As alternatives are accepted and formalized, the current system is modified appropriately.

The first step in the impact analysis lies in identifying the need for alternatives, and in providing the necessary alternative data This data may describe alternative equipment, operations considerations, design approaches, support combinations, and unit cost data. This data is developed and stored as part of the CDB.

The first step is arrived at by two different paths, one internal and the other external to CHRT. The internal path is the evaluation of a specific configuration for high drivers. It was previously stated that a high driver was a design or item of equipment that created an excessive human resource-related requirement. Again, excessive is a judgemental term and must be defined in order to use this particular CHRT function. The method of definition is relative, and can range from an automatic screening level established for computerized data to a visual review and personal evaluation of the CHRT data. The external path is to identify through a review of

the DODTs, a design point where alternative designs are being considered or to identify alternative design, maintenance, operations, and support approaches which either directly or through a resulting design change affects human resources.

A very simple example of a design alternative which would have an effect on human resources would be a newly designed unit which is considered a replacement for an existing, supportable unit. The new unit could require different training, manuals, support equipment, skills, spares, and number of assigned technicians.

Examples of maintenance and support alternatives which directly affect human resources would be a decision to require a minimum of two airmen per task rather than one as a safety measure, or a decision to use built-in test equipment rather than standard support equipment for fault isolation. Both decisions directly affect personnel, skills, training, and tech data. On the other hand, a change in required mean flight hours between maintenance actions could result in a relaxation or tightening of design which, in turn, would indirectly affect the types of maintenance actions and possibly the number of technicians.

The variations possible for alternatives are innumerable because of the many factors involved. The number of practical variations, however, should be much less since many variations can be readily deemed impractical, ill advised, or evidently similar in effect. CHRT will be used to determine and then evaluate viable alternatives.

Once a decision to consider a specific alternate has been made, portions of the CHRT process must be reiterated for each alternative:

- The SOC model must be temporarily updated to reflect any parameter change peculiar to the alternative
- The DODTs may be updated to reflect alternatives considered
- The equipment listing must be updated to reflect end-item and support equipment changes
- The integrated requirements and maintenance task analysis must be reaccomplished to the degree necessary to determine any significant change in the maintenance event, maintenance activity, or personnel availability data. An LCOM simulation run may be needed.
- The CDB must be thoroughly updated so that valid HR and cost data may be obtained.

Only after accomplishing the above actions for each alternative will the CHRT output validly reflect the alternative. This data may then be viewed in perspective with other technical, cost, schedule, and support consolidations for a decision to be made. Once an alternative is chosen, the prime data must be modified to reflect the choice and a new current configuration must be generated.

5.3 THE SOC MODEL

One of the primary functions of the CHRT process and of the impact analysis in particular is to provide timely system ownership cost information. The SOC model provides detailed and timely cost information on support, technical data, training, and personnel. Detailed data on the SOC model is provided in AFHRL-TR-78-6(III).

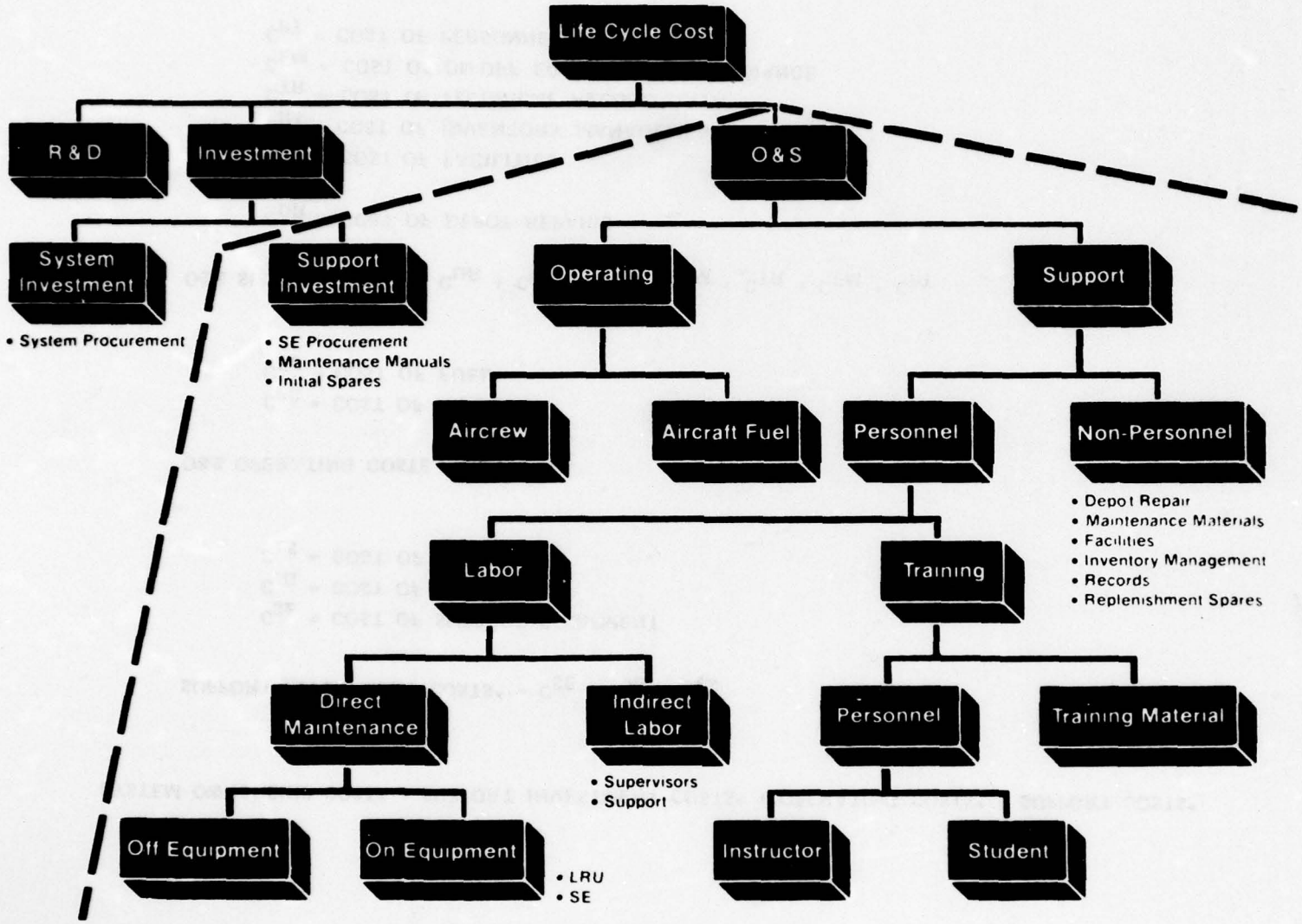
The hierarchy of weapon system cost is shown in Figure 4-1. Life cycle cost is shown as divided into R&D, investment, and operating and support costs. System ownership cost is defined as the following specific cost areas:

- Support investment costs
- O&S operating costs
- O&S support costs.

CHRT provides detailed human resources impact in the system ownership cost area. The SOC model is therefore a major process within CHRT since it translates the human resources data into cost implications. The SOC model equations are summarized in Table 4-1.

Basically, the SOC model provides a standardized means of generating and presenting ownership cost data in the areas previously mentioned. Specifically, it:

- Provides a vehicle compatible with the CHRT process
- Generates the necessary human resource data in a structured and comprehensive format
- Utilizes the same model throughout the weapon system acquisition process and provides detailed information where required
- Standardizes prime data sources during each acquisition phase.



HIERARCHY OF LIFE CYCLE COST

Figure 5-1

SYSTEM OWNERSHIP COST* = SUPPORT INVESTMENT COSTS* + OPERATING COSTS* + SUPPORT COSTS*

SUPPORT INVESTMENT COSTS* = $C_{SE} + C_{JG} + C_{LS}$

C_{SE} = COST OF SUPPORT EQUIPMENT
C_{JG} = COST OF JOB GUIDES
C_{LS} = COST OF LRU SPARES

O&S OPERATING COSTS = $C_{PC} + C_{FC}$

C_{PC} = COST OF AIRCREW
C_{FC} = COST OF FUEL

O&S SUPPORT COSTS = $C_{DR} + C_{MM} + C_{FA} + C_{IM} + C_{TR} + C_{EM} + C_{PT}$

C_{DR} = COST OF DEPOT REPAIRS

C_{FA} = COST OF FACILITIES
C_{IM} = COST OF INVENTORY MANAGEMENT
C_{TR} = COST OF TECHNICAL RECORD DATA
C_{EM} = COST OF ON-OFF EQUIPMENT MAINTENANCE
C_{PT} = COST OF PERSONNEL TRAINING

*All costs expressed in annual dollars, i.e., dollars/year.

THE SYSTEM OWNERSHIP COST MODEL FOR CHRT

Table 5-1

5.4 APPLICATION OF THE IMPACT ANALYSIS

The impact analysis is applied in basically the same manner, but with some variation in each acquisition phase.

Conceptual Phase

During the conceptual phase, the reference system and the major current system configurations under consideration are established in the CHRT CDB. This is described in AFHRL-TR-78-6(I). System level design option decision trees are evolved for each current system and where necessary for specific subsystems. A minimal IRTA is performed to establish initial HR requirements for each system. These HR requirements along with an associated SOC estimate are then evaluated to simply determine whether or not the major configurations fall within the constraints established. The activities within CHRT may be iterated through the impact analysis to the degree that time, data, and program office or contractor resources allow in order to evaluate the HR and cost impact of various system level alternatives.

It is in the conceptual phase that the basic design, maintenance, operations, and support decisions are made. Unfortunately, once the decision is made, the commitment is near impossible to reverse. It is also these very basic decisions: design (e.g., number of engines), maintenance (e.g., $\overline{R}$), operations (e.g., crew composition), and support (e.g., test equipment concept) that have a major impact during the operational phase. This impact presents itself in human resource utilization and system ownership cost. CHRT, through the impact analysis, provides the vehicle to predict both human-resource and cost impact for any design, maintenance, operations, and support alternative. This data then becomes a major factor in the decision as to which alternative to implement.

Validation Phase

The configuration(s) approved for continued investigation during the validation phase are established in the CDB as the baseline system(s) along with the reference system. A current system is also set up for each major configuration, and it is to this that all alternate considerations for a specific configuration are applied. The current system(s) is intially the same as the baseline system(s), but it changes as alternates are evaluated and accepted.

The impact analysis has its widest application during the validation phase because it allows not only a validation of the various design but also of the possible maintenance, operations, and support concepts under consideration. The validation phase is the time when the optimum system design is evolved, and when the various concepts are expanded and detailed to provide plans for the full scale development phase. It is also the time when many final decisions are made. These decisions directly affect system ownership costs. The impact analysis can provide the necessary and realistic predictive data to make sound decisions.

Full Scale Development Phase

Impact analysis in the full scale development phase is applied to the current configuration derived from the full scale development baseline system. The manner in which it is applied is similar to that in the validation phase except it is now used to support the detailed design effort rather than the system level design effort. At this level, alternatives may not cause as significant an impact as at the system level, but differences will be apparent because of the increased detail and accuracy of the CHRT data. CHRT will have provided a well prepared framework for the detailed level effort of this phase.

Section 6
IMPLEMENTATION OF CHRT/CDB

At this time, the manpower, resources, and cost of accomplishing the CHRT/CDB effort on a weapon system development program similar to the AMST can only be estimated. Several assumptions have been made in this estimate stated:

1. CHRT/CDB effort would be applied to the total weapon system
2. Only changes to present practices will be considered
3. This hypothetical implementation would be the first application that follows Phase II of 1959-002
4. This estimate is for a minimum-usage CHRT, with no iterative trade-off studies in the validation phase
5. This estimate assumes the use of a non-computerized version of CHRT/CDB and an acquisition cycle of three years
6. Manpower estimated at $50K per year, bottom line.

CHRT/CDB Activities	Manpower (person-years)	Resources (dollars)	Cost (dollars)
Reference System Evaluation (no LCOM)	1		50K
Begin earlier (conceptual phase)			0
Personnel data			0
Acquire data including early LCOM task analysis	2		100K
Analyze $\overline{M}$ activity and task condition matrices	1		50K
IRTA (MMM/ISD/JGD)	-4		-200K
ISD/JGD Concept/Plan/ Program	2		100K
SOC Analysis	2		100K
Impact Analysis	1.5		•75K
Maintain CDB	2.5	—	125K
TOTAL	8	0	400K

This estimate will be re-evaluated upon completion of the Phase II demonstration. It should, however, be further refined and validated during application to a total system acquisition.

The many benefits that can be derived from the implementation of CHRT/CDB will most likely raise the demand for its use, and consequently the cost of supplying the CHRT service--particularly during the validation phase. However, in almost all cases of increased CHRT application, the cost is expected to be significantly lower than the savings in the outyear support costs. The implementation of the CDB and an IRTA represents a savings of four person-years over the cost of implementing separate data bases for the five human resource technologies.

ABBREVIATIONS AND ACRONYMS

The following abbreviations and acronyms are used with the CHRT.

A	availability
A/C	aircraft
AFHRL	Air Force Human Resources Laboratory
AFSC	Air Force specialty code
AMST	Advanced Medium STOL Transport
ATIM	annotated task identification matrix
CDB	consolidated data base
CND	cannot duplicate
CHRT	coordinated human resource technology
DSARC	Defense Systems Acquisition Review Council
FOMM	functionally organized maintenance manuals
FPJPA	fully proceduralized job performance aids
HRDT	human resources in design tradeoffs
ILS	integrated logistic support
ILSP	integrated logistic support plan
IRTA	integrated requirements and task analysis
ISD	instructional system development
JGD	job guide development
JPA	job performance aid
LCC	life cycle cost
LCOM	logistic composite model
LSA	logistic support analysis
LSAR	logistic support analysis record
$\overline{M}$	maintainability
MFHBMA	mean flight hours between maintenance actions
MMH/FH	maintenance man hours/flight hour
MMM	maintenance manpower modeling
MTTR	mean time to repair
NRTS	not repairable this station
PTIM	preliminary task identification matrix
$\overline{R}$	reliability
ROC	required operational capability
SIMM	symbolic integrated maintenance manuals
SOC	system ownership cost
STOL	short field takeoff and landing

DEFINITIONS

The following definitions are applicable to CHRT.

algorithms - mathematical formulas and procedures, pre-programmed into the system, which will translate data from base files and/or sub-files into data elements which quantify human resource requirements and ownership cost.

baseline data - data which reflects the weapon system approved for further development at a DSARC milestone.

background data - all weapon system program data from which CDB data is drawn.

behavior - any human action generally defined by a stimulus (cue) and response. A basic stimulus-organism-response constituent of behavior comprising the smallest logically defineable set of perceptions, decisions, and responses required to complete a task. Involves, for example, identifying a specific signal on a specific display, deciding on a single action, activating a specific ontrol, and noting the feedback signals of response adequacy.

cue - a stimulus to a response. For example, a cue could consist of a meter reading, physical appearance, flashing light, etc. Responses to cues consist of such activities as turning a knob, setting a switch, reading a value on a display, etc. Often a response can be a cue for a succeeding response.

current data - data which reflects the updated and accepted weapon system configuration at any specific time between the baseline of each phase.

data base - a grouping of base files by category (or defined set) representing all the basic data for a specific generation of equipment.

data element - a grouping of information and units which has a unique meaning and which may have subcategories (data items) of distinct units or values.

data element definition - a narrative definition of the data element in sufficient detail to present a clear and complete understanding of the precise data or element of information that the data element represents.

detailed task data - task statements to the level required to make the final ISD/JGD decision, to make tradeoffs within the instructional system itself and finally to develop the products; course, media, performance measurement, and job guide documentation.

extended -11 file - the format used by the Logistics Composite Model (LCOM) to identify the maintenance tasks and the order in which they are to be done, along with the time and resources needed to accomplish each task.

file - a grouping of one type of input variable or a derived quantity thereof for a particular ID. All of the input data items are grouped for a comparable level (e.g., flightline, shop).

job - a group of tasks performed by a specific individual.

general task data - task statements to the level required to make a basic decision regarding manpower requirements and the applicability of training courses, media, performance measurement and job guides documentation (i.e., the ISD/JGD decision). For maintenance, the task level would be to the LRU (e.g., repair LRU) but would not include development of the specific task statements that encompassed the task.

line replaceable unit (LRU) - a combination of parts, subassemblies, and assemblies mounted together, normally capable of independent operation in a variety of situations. An LRU is normally directly accessible and can be removed without prior disassembly of the equipment or group. (MIL-STD-280). The LRU is the first level of assembly below the subsystem that is carried as a line item of supply at the base level and is usually the highest level of assembly that is removed and replaced, as a unit, on the flightline.

maintenance event - consists of one or more maintenance functions. These maintenance events are specifically symbolized and identified as:

A - setup support equipment
T - troubleshoot on aircraft (A/C)
C - cannot duplicate (CND) on A/C
M - minor repair on A/C
R - remove & replace (R&R)
V - verification of $\overline{R}$ or $\overline{M}$ events
W - bench check and repair in shop
K - bench check and CND in shop
N - not repairable this station (NRTS)
H - scheduled checks, inspections, or service

maintenance function - a behavioral term associated with a task. Specifically: adjust, align, calibrate, checkout, troubleshoot, clean, disassemble/assemble, inspect, lubricate, operate, remove/install, repair, service are maintenance functions (ref. AFHRL-TR-73-43(I)).

reference data - data which reflects a reference weapon system. The reference system is the system(s) that the new acquisition will specifically replace and consequently must be shown to be less cost/effective in the long run. Reference data is compiled in the conceptual phase and retained as a supplement to the CDB. It would not be expected to change since it is normally derived from operations, performance, support, and cost information on existing systems. In some cases there may be no reference system(s).

shop replaceable unit (SRU) - the SRU is a lower level assembly or subassembly within an LRU normally formed together to perform a specific function. An SRU is normally repaired or replaced only within the base (intermediate level) shops rather than on the flight line.

skill level - the fourth number within an AFSC identifying a level of aptitude, training, experience, knowledge, skills, and responsibility.

subsystem - a set or combination of LRUs and/or assemblies generally physically separated when in operation connected together or used in association to perform an operational function within the system. It is the level of equipment identified by three characters in the work unit code structure (e.g., 7]B TACAN set) or as a four-digit ID number (e.g., AN/2 TACAN).

system - a major subset of a weapon system comprised of individual functional groupings and their integration within the weapon system (e.g., avionics, landing gear, electrical, etc.).

task - a composite of related activities (behaviors) performed by an individual and directed toward accomplishing a specific amount of work within a specific work context. These activities usually occur in temporal proximity with the same displays and controls and have a common purpose. Each task has a goal.

task analysis - an analytic process employed to determine the specific behaviors required of a human component in a man-machine system. It involves determining, usually on a time basis, the detailed performance required of men, the nature and extent of their interactions with the machine and the effects of environmental conditions and malfunctions. It is the breakdown of behaviors into simple elements of perceptions, decisions, memory storage, motor output, etc.

task statement - a statement of the behavioral elements (in action verb form), the cues, and equipment description involved in a task.

weapon system - a complete system including all equipment, related facilities, material software, services, and personnel required for its operation and support to the degree that it can be considered a self-sufficient unit in its intended operational environment (AFSC DH1-1 pg. 7, Section 25).

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