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BASIC HUMAN FACTORS TASK DATA RELATIONSHIPS IN AEROSPACE SYSTEM DESIGN AND DEVELOPMENT

L. DUNCAN HANNAH

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FOREWORD

This report was prepared by Mr. L. Duncan Hannah, American Institute for Research (now at Lincoln College, Lincoln, Illinois) and Mr. Lawrence E. Reed of the Behavioral Sciences Laboratory, Aerospace Medical Research Laboratories. The research was conducted in support of Project 1710, "Human Factors in the Design of Training Systems," and Task 171006, "Personnel, Training, and Manning Factors in the Conception and Design of Aerospace Systems." Dr. Gordon Eckstrand was the Project Scientist and Mr. Melvin Snyder was the Task Scientist. The report was prepared during the period from August 1965 to December 1965.

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This technical report has been reviewed and is approved.

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Aerospace Medical Research Laboratories

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ABSTRACT

The generation, use, and flow of human factors task data in aerospace system design and development are described. The data are characterized by a process of continual transformation in content and form of presentation occurring throughout the iterative cycles of system development. The networks within which data flow are shown to be extensive in size, pervasive in nature, and complex in their dynamic relationships. These dynamic processes are illustrated in flow diagrams showing the relationships of human factors task data and their input/output elements in functional analysis for planning, specifications, task analysis, human engineering, reliability, maintainability, qualitative and quantitative personnel requirements information, training equipment planning information, and maintenance manuals.

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Contents

TABLE OF CONTENTS

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Contents

LIST OF FIGURES

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SECTION I

INTRODUCTION

This report describes the classes and sources of data used in the course of aerospace system design and development. Information gathered from human factors specialists and from pertinent documents (refs 10, 11, and 5), provided the basis for describing the important relationships of human factors task data. Data relationships, as used here, refer to data flow and the following characteristics of data:

1. The sources of data used either in whole or in part to produce new data
2. The transformations applied to the data sources to produce new data
3. The combination of data sources to produce new data
4. The uses to be made of data.

Human factors task data (or human factors data) were, for the purpose of this study, defined as including the qualitative and quantitative task and performance data for operator and maintenance personnel. These task data emphasize the behavioral data of human engineering, human learning and training, and training equipment, and include: (1) the demands that the system, man, or the situation make upon one another (e.g., the working environment, time criticality, performance accuracy); (2) discrete task information, such as expected or required task and skill parameters for either fixed or variable task procedures or both; (3) the applications of skills within the system mission segments and time base, where skills pertain to such functions as detecting and processing information, monitoring and communicating with or directing machines or humans, command decision making, feedback, and self-alignment or adjustment.

SECTION II

HUMAN FACTORS TASK DATA RELATIONSHIPS

Construction of Data Flow Diagrams

Because the data relationships in system design and development were found to be complex, they can be most clearly and economically presented in the form of flow diagrams (see figures 3 through 11 in appendix I). A brief description of the principal components in the flow diagrams will make them easier to interpret. The first step in constructing the diagrams was to identify intermediate human factors data products. These products are the results of efforts clearly identifiable as human factors as defined in the Introduction, and are related to each other and to primary data sources as shown in the flow diagrams. The diagrams also show the relations of each product to the phase of the system life cycle during which it is normally generated, and to the group of individuals (usually human factors specialists) responsible for its generation.

Although a large volume of information was used in developing the diagrams, the resulting networks are neither fixed nor exhaustive. Several factors make both

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completion and certainty impossible. One particular data item or kind of data might be obtained from reference works in one system, from private data in another, and from empirial observations in a third. In any one system, sources of data and methods of handling vary with time. And technological change, in hardware or methodology, makes any complete description of a system at some particular point in time, of historical interest only.

None of the flow diagrams should be viewed as an entity in and of itself. Rather, all the diagrams are part of a single entity which, if actually drawn in detail, would comprise a representative model of the relationships that exist among human factors data elements within products that are normally a part of complex system development. For example, while the diagram for task analysis (figure 5) shows which elements of task analysis are used directly in the development of maintainability analyses, it does not show all of the elements of traditional maintainability analyses. To examine the sources of all elements identified as part of maintainability analyses, one must refer to the diagram for that product (figure 8).

Limitations of the Data Flow Diagrams

Construction of the diagrams was based on a limited number of relatively short interviews and on information contained in documents relevant to and supplied or referred to by interviewees. As has been mentioned, it is impractical and probably impossible to detail all possible data relationships. The data elements and relationships presented were selected because they are critical to system development.

A feature common to many of the products generated from human factors data is their constant revision during system development, and many iterative cycles may be expected to occur. For example, many decisions made by human engineering are dependent on information obtained from task analyses. Task analyses must in turn be revised because of decisions made by human engineering. There are many such feedback loops present in system development. Indeed, it might be said that whenever a new data element is generated, previously generated data must be re-examined to assure their accuracy and relevance to the more recently developed data. This iterative cycle of generating data, comparing data, revising data, and again generating data is perhaps the most striking and pervasive feature of human factors task data handling in system development. In figures 1 through 11, however, only the most common feedback loops are shown.

Final operational products are shown as the final output of system development in figure 1. In figures 3 through 11, only major direct connections with intermediate products are shown because by the time a system is operational the relationships are highly complex with each final product, depending to some extent on all aspects of development.

Interpreting the Data Flow Diagrams

The diagrams are constructed to demonstrate, as simply as possible, a representative sample of data relationships found to be important because of magnitude and/or criticality to system development. The diagrams, as presented, cannot be further simplified or condensed without discarding useful information. While the information is presented as simply as possible, the diagrams remain rather complex and seem formidable to interpret. The following paragraphs are designed as a guide to the use and interpretation of the diagrams.

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Figure 1 summarizes sources of data, milestones of system development, intermediate products, and final operational products most directly related to human factors specialists' efforts in system development (see appendix II for the definitions of data products). These components of the overall data network are related to each other and to the phase in which they are usually completed or in which the major effort of their development occurs. This diagram is abstracted from a chart contained in "The Role of Human Factors Task Data in Aerospace System Design and Development" (ref 3). That chart presented a more complete network including all system milestones, products, data sources, generators, and users.

Presentation of the relationships among the components is straightforward in common flow diagram form. Those components which exist or are produced early in system development appear at the left of the diagram while those developed and used later appear to the right of these with final products shown at the extreme right. Feedback loops are not shown since practically all functions are iterative, and cycling of data between those components that contribute data to a specific component and those that use data from a specific component is the rule.

The developmental phases in which major efforts are accomplished are given as headings at the top of the diagram. Thus, Functional Analysis for Planning is seen to occur early in the Planning Phase while Task Analysis and Human Engineering efforts occur principally in the Design Phase when the system configuration is being developed.

One component shown in figure 1, Personnel Equipment Data (PED), is not made a part of the general flow. It is included because relevant manuals and regulations (refs 9 and 10) designate it as one of the elements of the personnel subsystem. In operation, however, PED becomes a combined product, including all other personnel subsystem products. Those products/components diagrammed in figure 1 that are subsummed under PED are enclosed by a dashed line.

Each of the cells or boxes in figure 1 is numbered, and whenever a component appears on the other diagrams, it is designated by the same number used in figure 1. In addition, these numbers are used in developing input and output codes used in figures 3 through 11.

Figures 3 through 11 present more detailed descriptions of data elements, for which the more general relationships are shown in figure 1. The nine components of the total network were selected as representing the important efforts of the specialist generating and using human factors task data. The components selected and the basic data flow relationships among them are shown in figure 2. In addition to the component name and code number, the figure number and the page on which it is located is given in each block.

Figure 2 is presented here as a guide (or key) to figures 3 through 11 in appendix I. Since the basic construction of the diagrams is essentially the same, a detailed description of each need not be presented. The principal components in one diagram (figure 5, Task Analysis) will serve as an example to more easily interpret and use the remaining diagrams.

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Elements

Figure 5 contains a list of classes of information used in developing certain products. These are in the column of the task analysis block, labeled Elements. In addition to the list of task analysis elements, partial lists of elements are included for the most directly relevant input and output products (see blocks 03 Functional Analysis for Planning, 06 Procurement Specifications, 12 Human Engineering, 13 Reliability, and 14 Maintainability in figure 5). This has been done to help maintain clarity and to reduce the need for frequent reference to other diagrams when studying the relationships of task analysis. The terms used here to denote data elements do not provide basic terms needed to classify data for computer storage purposes. Indeed, a list of classifiers for each of the data elements must be generated. The magnitude of the classification task is suggested by a list of classifiers developed for one part (visual) of a data element found in task analysis identified as machine output (I.D. No. 1129). This list is given in appendix III.

I.D. No.

Immediately to the left of the column labeled Elements is a column labeled I.D. No. The numbers in this column provide a code for each data element to help trace the source of information used in generating the elements and to indicate its eventual use in other products. The number is comprised of four digits. The first two digits indicate the component of which the element is a part, while the third and fourth digits identify the element within the component. Wherever these numbers appear on the diagrams they refer to the associated data element and component.

Input

The column labeled Input contains the I.D. numbers of data elements in other components used directly in the generation of the element they precede. For example, data element 0301 (the first element in component 03, Functional Analysis for Planning) contributes directly to the generation of data element 1101, the first identified element in component 11, Task Analysis. In addition to code numbers, the letters nn, xx, A, B, and C are sometimes used. The meaning of these letters are given in the legend for each diagram.

Output

In like manner, the code numbers following data element 1101 in the column labeled Output, are those elements which made use of the information in element 1101. Thus, the data elements identified by the code numbers 1506, 1509, 1811, and 1831 made use of the information contained in data element 1101. Data elements 1506 and 1509 refer to elements found in component 15, Qualitative and Quantitative Personnel Requirements Information (QQPRI). Data elements 1811 and 1831 refer to elements found in component 18, Maintenance Manuals.

An Example of Data Relationships

Following through the procedures just described will help clarify the interpretation of the diagrams. Using figure 5, Task Analysis, as an example, one element of task analysis is "Minimum number of personnel required to perform." This element is associated with I.D. No. 1117. Reference to the input data elements to I.D. No. 1117 indicates that the information used in generating that data element is found in elements

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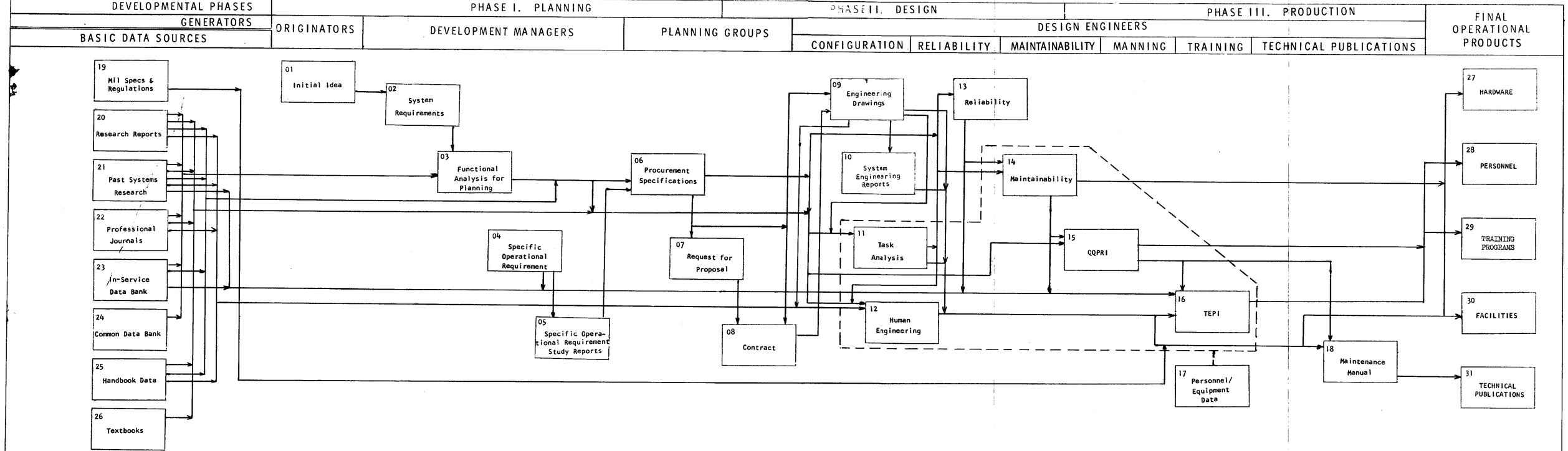

Fig. 1 Relationships among human factors data products generated during weapon system development.

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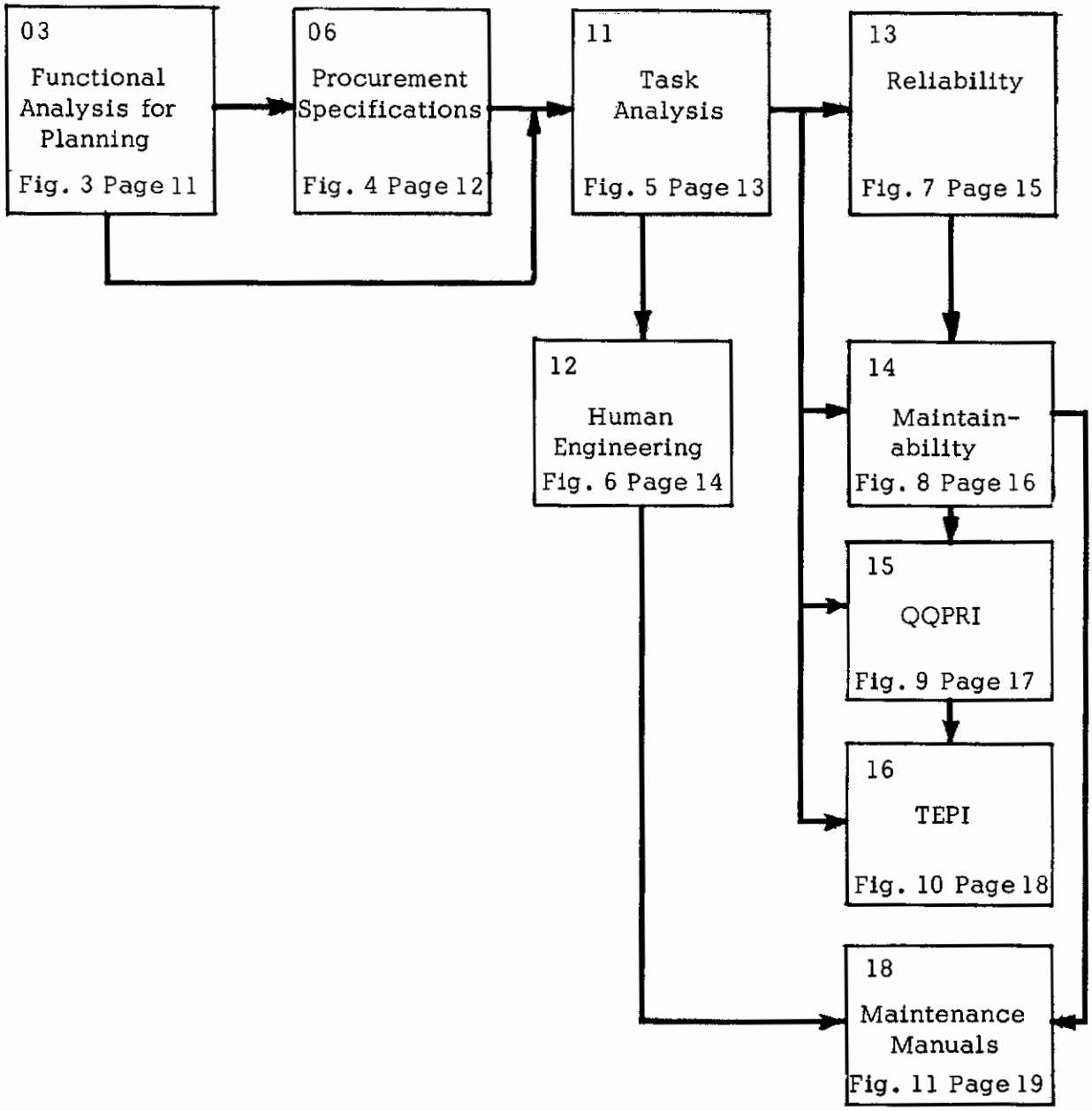

Figure 2. Basic Relationships and Key to Figures 3 through 11.

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associated with component 03, Functional Analysis for Planning. Statements concerning the number and kinds of personnel (I.D. No. 0308 and 0309, respectively) predicted as being necessary to operate the system as well as statements relevant to sequence of performance of functions (I.D. No. 0310), appear in this component. In addition, it is indicated (I.D. No. 21xx) that information generated in the development of past systems is frequently used in generating the data element under consideration. Finally there is an indication (I.D. "A") that information generated within the product (task analysis) may be used in generating the data element.

To identify where data element 1117, once generated, is used, it is necessary to refer to the output codes. The codes show that data element 1117 contributes information used in generating 12 elements (I.D. Nos. 1405, 1406, 1409, 1410, 1413 through 1420) in the product labeled Maintainability. The information contained in the data element is useful here since the items generated are maintenance manhours per operating hour, maintenance manhours per specific maintenance action, mean corrective and preventive maintenance hours, and operating costs.

Further use is made of element 1117 in the QQPRI effort as indicated by the output codes (1512, 1513, 1514, 1516, 1517, and 1518), but data elements of QQPRI are not found in figure 5. Reference to figure 2 shows that QQPRI relationships are diagrammed in figure 9.

Figure 9 shows that element 1117 is used in the generation of elements in the QQPRI, such as, type and number of personnel required, team performance, position descriptions, work shifts, and the number and type of personnel to be assigned to each work shift. In like manner, the remaining output code numbers following element 1117 (1815, 1826, 1835, and 1846) indicate that the element is used in generating data on job crew size for each of the various kinds of maintenance activities described in the maintenance manuals.

The data inputs and outputs illustrated in the diagrams represent a process of continual transformation in content and form. Content of data elements is changed by combining other data elements and the form is changed to make data more readily available for use when needed. In the example just discussed, the general statements for estimating the kind and number of personnel and a description of sequential steps of functions for Functional Analysis for Planning are found in narrative form. These data are later processed and combined with other data to provide detailed estimates of the number of personnel required to perform each task and are reported as a set of discrete numbers and descriptors on a task analysis form. Subsequently, the data are reprocessed and combined with still more data to generate numbers and types of personnel required to perform certain jobs, mean down times of system equipment and costs of operation, probably in tabular form in the QQPRI and maintainability documents.

The sources and uses of all data elements presented in the diagrams can be traced using the same steps and procedures used in the example just discussed. When analyzed in this manner, the diagrams present a graphic picture of the dynamic processes of human factors task data flow and transformation in system development. The data elements presented are only representative, not exhaustive of those in use today. Nor are those presented absolute and unchangeable. They will change as system requirements and characteristics change. Finally, the data elements presented do not in themthelves constitute a systematic classification scheme which can be used for the storage and retrieval of data.

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SECTION III

CONCLUSIONS

The presentation made in this report is primarily descriptive in nature. No explicit hypotheses were developed or tested. There is, however, an implicit hypothesis that human factors task data networks in the context of system development are extensive in size, pervasive in nature, and complex in their dynamic relationships. The presentation of the data networks seems to support this hypothesis, although no measures of absolute magnitude, or relative pervasiveness and complexity can be made. The following observations and conclusions seem to be warranted.

Human factors task data do indeed constitute a large body of information used throughout system development and use of the information is essential to the system development process. The data base is extensive and to date no single data source has been sufficient for system development.

Human factors task data are used in some way through every stage of system development. Many elements of human factors task data are used repeatedly and contribute to many products. Sources for generation of human factors task data elements are usually multiple. The data are characterized by frequent recombination and transformation in form as dictated by requirements of users of the data.

A high percentage of human factors task data used in system development can be cast in the form of the task analysis. The diagrams show that a rather large amount of human factors data is based on data elements originally generated in the development of task analyses early in system development. Therefore, during the development of human factors task classification, close consideration must be given to the advantages of basing a system on a form similar to task analysis as now used.

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APPENDIX I

RELATIONSHIPS AMONG DATA ELEMENTS

(FIGURES 3 THROUGH 11)

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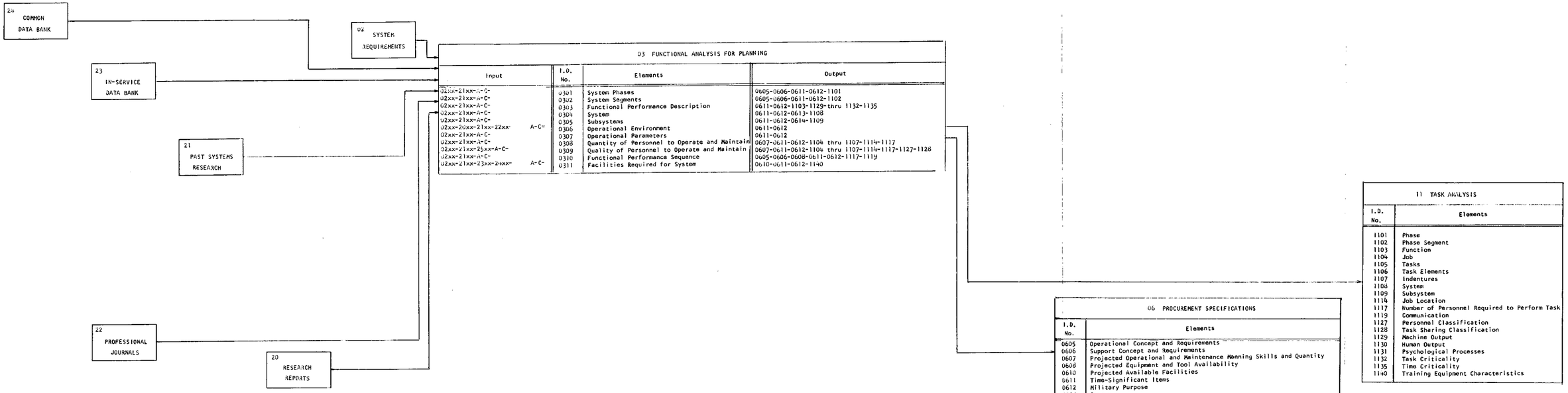
DEVELOPMENTAL PHASES	PHASE I. PLANNING		PHASE II. DESIGN
GENERATORS	DEVELOPMENT MANAGERS	PLANNING GROUPS	DESIGN ENGINEERS
BASIC DATA SOURCES			CONFIGURATION



Input	I.D. No.	Elements	Output
02xx-21xx-A-C-	0301	System Phases	0605-0606-0611-0612-1101
02xx-21xx-A-C-	0302	System Segments	0605-0606-0611-0612-1102
02xx-21xx-A-C-	0303	Functional Performance Description	0611-0612-1103-1129-thru 1132-1135
02xx-21xx-A-C-	0304	System	0611-0612-0613-1108
02xx-21xx-A-C-	0305	Subsystems	0611-0612-0614-1109
02xx-20xx-21xx-22xx- A-C-	0306	Operational Environment	0611-0612
02xx-21xx-A-C-	0307	Operational Parameters	0611-0612
02xx-21xx-A-C-	0308	Quantity of Personnel to Operate and Maintain	0607-0611-0612-1104 thru 1107-1114-1117
02xx-21xx-25xx-A-C-	0309	Quality of Personnel to Operate and Maintain	0607-0611-0612-1104 thru 1107-1114-1117-1127-1128
02xx-21xx-A-C-	0310	Functional Performance Sequence	0605-0606-0608-0611-0612-1117-1119
02xx-21xx-23xx-24xx- A-C-	0311	Facilities Required for System	0610-0611-0612-1140

I.D. No.	Elements
0605	Operational Concept and Requirements
0606	Support Concept and Requirements
0607	Projected Operational and Maintenance Manning Skills and Quantity
0608	Projected Equipment and Tool Availability
0610	Projected Available Facilities
0611	Time-Significant Items
0612	Military Purpose
0613	System
0614	Subsystems

I.D. No.	Elements
1101	Phase
1102	Phase Segment
1103	Function
1104	Job
1105	Tasks
1106	Task Elements
1107	Indentures
1108	System
1109	Subsystem
1114	Job Location
1117	Number of Personnel Required to Perform Task
1119	Communication
1127	Personnel Classification
1128	Task Sharing Classification
1129	Machine Output
1130	Human Output
1131	Psychological Processes
1132	Task Criticality
1135	Time Criticality
1140	Training Equipment Characteristics

LEGEND:

A -- Data generated within a product (may be entirely new, or the result of the recombination of foregoing products).
C -- Data which are presented in the form of figures and graphs.
xx -- Substitute identification number for data element which has not been defined.

Fig. 3 Relationships among the elements of the functional analysis for planning and its input and output elements.

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DEVELOPMENTAL PHASES → | PHASE I. PLANNING | PHASE II. DESIGN | PHASE III. PRODUCTION

GENERATORS → | DEVELOPMENT MANAGERS | PLANNING GROUPS | DESIGN ENGINEERS

BASIC DATA SOURCES | | | CONFIGURATION | RELIABILITY | MAINTAINABILITY | MANNING | TRAINING

23 IN-SERVICE DATA BANK

02 SYSTEM REQUIREMENTS

21 PAST SYSTEMS RESEARCH

25 HANDBOOK DATA

20 RESEARCH REPORTS

03 FUNCTIONAL ANALYSIS FOR PLANNING

I.D. No.	Elements
0301	System Phases
0302	System Segments
0304	System
0305	Subsystems
0308	Quantity of Personnel to Operate and Maintain
0309	Quality of Personnel to Operate and Maintain
0310	Functional Performance Sequence
0311	Facilities Required for System

04 SDR

05 SDR STUDY REPORTS

06 PROCUREMENT SPECIFICATIONS

Input	I.D. No.	Elements	Output
02xx-21xx-A	0601	Operating Time/Time Unit	1401-1402-1403-1405-1406-1407-1410-1414-1415 thru 1421
05xx-21xx-25xx-A	0602	Minimum Reliability Requirements	1115-1133-1201 thru 1224-1302
05xx-21xx-25xx-A	0603	Minimum Reliability Confidence, Level Requirements	1115-1133-1201 thru 1224-1303
05xx-21xx-25xx-A	0604	Corrective Maintenance Free Time/Time Unit	1305
02xx-0301-0302-0310-21xx-A	0605	Operational Concept and Requirements	1201 thru 1224
02xx-0311-0302-0310-21xx-A	0606	Support Concept and Requirements	1201 thru 1224
0308-0309-04xx-21xx-23xx-A	0607	Projected Operational and Maintenance Manning Skills and Quantity	1120
02xx-0311-04xx-A	0608	Projected Equipment and Tool Availability	
02xx-04xx-20xx-21xx-25xx-A	0609	Operational and Support Environmental Conditions	1201 thru 1224
0311-04xx-23xx-25xx-A	0610	Projected Available Facilities	1140
03xx-04xx	0611	Time Significant Items	1617
03xx-04xx	0612	Military Purpose	1502
03xx-04xx	0613	System	1108
0304-04xx	0614	Subsystems	1109
0305-04xx	0615	Components	1110
04xx-05xx	0616	Subcomponents	1111
04xx-05xx	0617	Sub-subcomponents	1112
05xx	0618	Parts	1113
05xx			

07 REQUEST FOR PROPOSAL

08 CONTRACT

09 ENGINEERING DRAWINGS

11 TASK ANALYSIS

I.D. No.	Element
1108	System
1109	Subsystem
1110	Component
1111	Subcomponent
1112	Sub-subcomponent
1113	Part
1115	Frequency of Job Performance
1120	Difficulty Index
1133	Frequency of Task Performance
1140	Training Equipment Characteristics

12 HUMAN ENGINEERING

I.D. No.	Elements
	A. Machine Output
1201	Visual
1202	Audio
1203	Tactual
1204	Proprioception
1205	Vestibular Sense
1206	Somesthesis
1207	Smell
1208	Pain
1209	Temperature
	B. Human Output
1210	Control
1211	Non-control
1212	Communication
	C. Psychological Processes
1213	Auditory-vocal
1214	Motor
1215	Vision
1216	Coordination
1217	Tactual
1218	Decision Making
1219	Symbolic Data Operations
	D. Task Area Environment
1220	Physical
1221	Psychological
1222	Physiological
1223	Movement Restraints
1224	E. Safety Precautions and Emergency Procedure

13 RELIABILITY

I.D. No.	Elements
1302	Reliability Index
1303	Reliability Confidence Level
1305	Mean Operation Time/Time Unit

14 MAINTAINABILITY

I.D. No.	Elements
1401	Mean Down Time
1402	Maximum Down Time
1403	Mean Time Between Maintenance Action
1405	Maintenance Man Hours/Operating Hour
1406	Maintenance Man Hours/Specific Maintenance Action
1407	Maintenance Hours/Operating Hour
1410	Maintenance Costs/Operating Hour
1414	Inherent Availability ((ideal probability)
1415	Mean Corrective Maintenance Time
1416	Mean Preventive Maintenance Time
1417	Mean System Maintenance Time
1418	Total Maintenance Time/Time Unit
1419	Maximum Corrective Maintenance Time
1420	Operational Availability (ideal probability)
1421	Mean Time Between Failure

15 QQPRI

I.D. No.	Element
1502	Military Purpose

16 TEPI

I.D. No.	Element
1617	Availability of Training

LEGEND:

A -- Data generated within a product (may be entirely new, or the result of the recombination of foregoing products).
xx -- Substitute identification number for data element which has not been identified.
nn -- Indicates all data elements within any given product.

Fig. 4 Relationships among the elements of the procurement specifications and their input and output elements.

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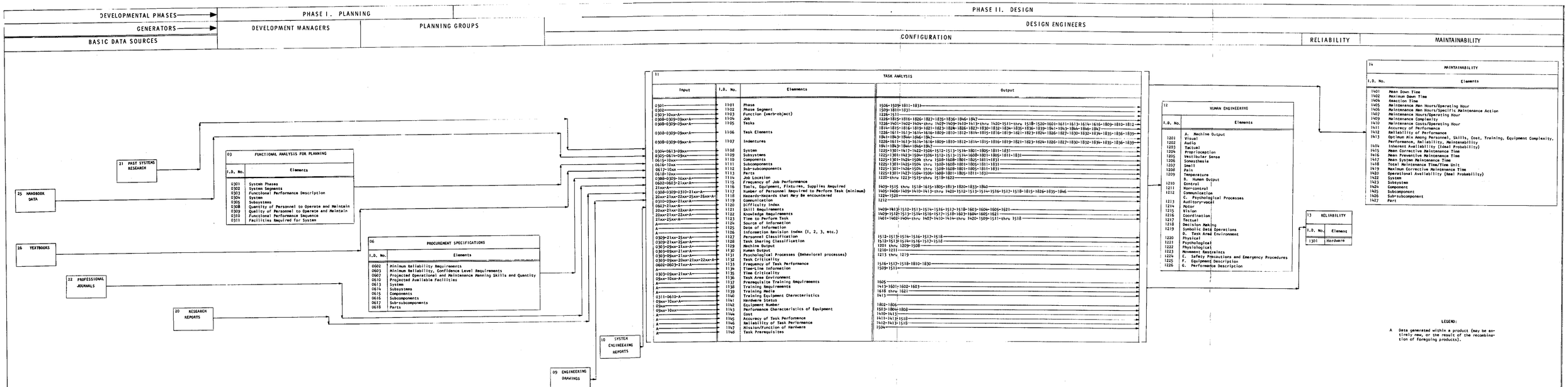

Fig. 5 Relationships among the elements of the task analysis and its input and output elements.

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DEVELOPMENTAL PHASES →	PHASE I. PLANNING	PHASE II. DESIGN		PHASE III. PRODUCTION		
GENERATORS →	PLANNING GROUPS	DESIGN ENGINEERS				
BASIC DATA SOURCES		CONFIGURATION		RELIABILITY	TRAINING	TECHNICAL PUBLICATIONS

21 PAST SYSTEMS RESEARCH

25 HANDBOOK DATA

22 PROFESSIONAL JOURNALS

20 RESEARCH REPORTS

09 ENGINEERING DRAWINGS

06 PROCUREMENT SPECIFICATIONS

I.D. No.	Elements
0602	Minimum Reliability Requirements
0603	Minimum Reliability Confidence Level Requirements
0605	Operational Concept and Requirements
0606	Support Concept and Requirements
0609	Operational and Support Environmental Conditions

11 TASK ANALYSIS

I.D. No.	Elements
1103	Function
1104	Job
1105	Tasks
1106	Task Elements
1107	Indentures
1108	System
1109	Subsystems
1110	Components
1111	Subcomponents
1112	Sub-subcomponents
1113	Parts
1114	Job Function
1118	Hazards
1129	Machine Output
1130	Human Output
1131	Psychological Processes

12 HUMAN ENGINEERING

Input	I.D. No.	Elements	Output
0602-0603-0605-0606-0609-09XX-1129-20XX-21XX-22XX-25XX-A-B-		A. Machine Output	1612-
0602-0603-0605-0606-0609-09XX-1129-20XX-21XX-22XX-25XX-A-B-	1201	Visual	1612-
0602-0603-0605-0606-0609-09XX-1129-20XX-21XX-22XX-25XX-A-B-	1202	Audio	1612-
0602-0603-0605-0606-0609-09XX-1129-20XX-21XX-22XX-25XX-A-B-	1203	Tactual	1612-
0602-0603-0605-0606-0609-09XX-1129-20XX-21XX-22XX-25XX-A-B-	1204	Proprioception	1612-
0602-0603-0605-0606-0609-09XX-1129-20XX-21XX-22XX-25XX-A-B-	1205	Vestibular Sense	1612-
0602-0603-0605-0606-0609-09XX-1129-20XX-21XX-22XX-25XX-A-B-	1206	Somasthesia	1612-
0602-0603-0605-0606-0609-09XX-1129-20XX-21XX-22XX-25XX-A-B-	1207	Smell	1612-
0602-0603-0605-0606-0609-09XX-1129-20XX-21XX-22XX-25XX-A-B-	1208	Pain	1612-
0602-0603-0605-0606-0609-09XX-1129-20XX-21XX-22XX-25XX-A-B-	1209	Temperature	
		B. Human Output	
0602-0603-0605-0606-0609-09XX-1130-20XX-21XX-22XX-25XX-A-B-	1210	Control	1612-
0602-0603-0605-0606-0609-09XX-1130-20XX-21XX-22XX-25XX-A-B-	1211	Non-control	1612-
0602-0603-0605-0606-0609-09XX-1130-20XX-21XX-22XX-25XX-A-B-	1212	Communication	1612-
		C. Psychological Processes	
0602-0603-0605-0606-0609-09XX-1131-20XX-21XX-22XX-25XX-A-B-	1213	Auditory - vocal	1612-
0602-0603-0605-0606-0609-09XX-1131-20XX-21XX-22XX-25XX-A-B-	1214	Motor	1612-
0602-0603-0605-0606-0609-09XX-1131-20XX-21XX-22XX-25XX-A-B-	1215	Vision	1612-
0602-0603-0605-0606-0609-09XX-1131-20XX-21XX-22XX-25XX-A-B-	1216	Coordination	1612-
0602-0603-0605-0606-0609-09XX-1131-20XX-21XX-22XX-25XX-A-B-	1217	Tactual	1612-
0602-0603-0605-0606-0609-09XX-1131-20XX-21XX-22XX-25XX-A-B-	1218	Decision Making	1612-
0602-0603-0605-0606-0609-09XX-1131-20XX-21XX-22XX-25XX-A-B-	1219	Symbolic Data Operations	1612-
		D. Task Area Environment	
0602-0603-0605-0606-0609-09Xx-1114-20XX-21XX-22XX-25XX-A-B-	1220	Physical	1612-
0602-0603-0605-0606-0609-09XX-1114-20XX-21XX-22XX-25XX-A-B-	1221	Psychological	1612
0602-0603-0605-0606-0609-09XX-1114-20XX-21XX-22XX-25XX-A-B-	1222	Physiological	1612-
0602-0603-0605-0606-0609-09XX-1114-20XX-21XX-22XX-25XX-A-B-	1223	Movement Restraints	1612-
0602-0603-0605-0606-0609-09XX-1118-20XX-21XX-22XX-25XX-A-B-C-	1224	E. Safety Precautions and Emergency Procedures	1612-1817-1818-1828-1829-1837-1838-1848-1849-
1108-1109-1110-1111-1112-1113	1225	F. Hardware Description	1612-
1103 -1104-1105-1106-1107	1226	G. Performance Description	1612-

16 TEPI

I.D. No.	Element
1612	Human Engineering for Training Equipment

18 MAINTENANCE MANUALS

I.D. No.	Elements
1817	Safety Precautions
1818	Emergency Procedures
1828	Safety Precautions
1829	Emergency Procedures
1837	Safety Precautions
1838	Emergency Procedures
1848	Safety Precautions
1849	Emergency Procedures

LEGEND:

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B -- Narrative information generated in response to report requirements.
C -- Data which are presented in the form of figures and tables.
XX -- Substitute identification number for data element which has not been identified.

Fig. 6 Relationships among the elements of human engineering and its input and output elements.

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PHASE I. PLANNING	PHASE II. DESIGN			PHASE III. PRODUCTION
PLANNING GROUPS	DESIGN ENGINEERS			
	CONFIGURATION	RELIABILITY	MAINTAINABILITY	TRAINING

06 PROCUREMENT SPECIFICATIONS

I.D. No.	Elements
0602	Minimum Reliability Requirements
0603	Minimum Reliability Confidence Level Requirements
0604	Corrective Maintenance Free Time/Time Unit

11 TASK ANALYSIS

I.D. No.	Elements
1108	System
1109	Subsystems
1110	Components
1111	Subcomponents
1112	Sub-subcomponents
1113	Parts

13 RELIABILITY

Input	I.D. No.	Elements	Output
1108-1109-1110-1111-1112-1113	1301	System, Subsystem, Sub-subsystem, Component, Part	1413-1609
0602-A	1302	Reliability Index	1401-1402-1403-1405-1406-1407-1408-1410-1413-thru 1421-1609
0603-A	1303	Reliability Confidence Level	1413-1609
A	1304	Duration of Operation	1413-1609
0604-A	1305	Mean Operation Time/Time Unit	1413-1609
A	1306	Maximum Operation Time/Time Unit	1413-1609
A	1307	Failure-modes	1408-1413-1609
A	1308	Failure Rate/Time Unit	1413-1609

14 MAINTAINABILITY

I.D. No.	Elements
1401	Mean Down Time
1402	Maximum Down Time
1403	Mean Time Between Maintenance Action
1405	Maintenance Man Hours/Operating Hour
1406	Maintenance Man Hours/Specific Maintenance Action
1407	Maintenance Hours/Operating Hour
1408	Frequency of Preventive Maintenance
1410	Maintenance Costs/Operating Hour
1413	Optimum Mix Among Personnel, Skills, Cost, Training, Equipment Complexity, Performance, Reliability, Maintainability
1414	Inherent Availability (Ideal Probability)
1415	Mean Corrective Maintenance Time
1416	Mean Preventive Maintenance Time
1417	Mean System Maintenance Time
1418	Total Maintenance Time/Time Unit
1419	Maximum Corrective Maintenance Time
1420	Operational Availability (Real probability)
1421	Mean Time Between Failure

16 TEPI

I.D. No.	Element
1603	Reliability of Training Equipment

LEGEND:

A -- Data generated within a product (may be entirely new, or the result of the recombination of elements of foregoing products).

Fig. 7 Relationships among the elements of reliability and its input and output elements.

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PHASE I. PLANNING	PHASE II. DESIGN			PHASE III. PRODUCTION	
PLANNING GROUPS	DESIGN ENGINEERS				
	CONFIGURATION	RELIABILITY	MAINTAINABILITY	MANNING	TRAINING

06 PROCUREMENT SPECIFICATIONS

I.D. No.	Element
0601	Operating Time/Time Unit

11 TASK ANALYSIS

I.D. No.	Elements
1105	Tasks
1108	System
1109	Subsystems
1110	Components
1111	Subcomponents
1112	Sub-subcomponents
1113	Parts
1116	Tools, Equipment, Fixtures, Supplies Required
1117	Number of Personnel Required to Perform Task
1121	Skill Requirements
1122	Knowledge Requirements
1123	Time to Perform Task
1138	Training Requirements
1140	Training Equipment Characteristics
1144	Cost
1145	Accuracy of Performance
1146	Reliability

13 RELIABILITY

I.D. No.	Elements
13nn	All Elements Within this Product
1302	Reliability Index
1307	Failure - modes
1308	Failure Rate/Time Unit

14 MAINTAINABILITY

Input	I.D. No.	Elements	Output
0601-1105-1123-1302-A	1401	Mean Down Time	1610
0601-1105-1123-1302-A	1402	Maximum Down Time	1610
0601-1302-A	1403	Mean Time Between Maintenance Action (MTBM)	1518-1610
1105-1123 -A	1404	Reaction Time	1610
0601-1105-1117-1123-1302-A	1405	Maintenance Man Hours/Operating Hour	1517-1610
0601-1105-1117-1123-1302-A	1406	Maintenance Man Hours/Specific Maintenance Action	1517-1610
0601-1105-1123-1302-A	1407	Maintenance Hours/Operating Hour	1610
1302-1307-1308-A[4]	1408	Frequency of Preventive Maintenance	1517-1610
1105-1116-1117-1121-1122-A	1409	Maintenance Complexity (e.g. number of people & skill levels, variety of AGE)	1610
0601-1105-1117-1123-1144-1302-A	1410	Maintenance Costs/Operating Hour	1610
1145	1411	Accuracy (of performance)	1610
1146	1412	Reliability (of performance)	1610
1105-1117-1121-1138-1140-1144-1145-1146-13nn-A	1413	Optimum Mix Among Personnel, Skills, Cost, Training, Equipment Complexity, Performance Reliability, Maintainability	1610
0601-1105-1117-1123-1302-A	1414	Inherent Availability (probability)	1610
0601-1105-1117-1123-1302-A	1415	Mean Corrective Maintenance Time	1518-1610
0601-1105-1117-1123-1302-A	1416	Mean Preventive Maintenance Time	1518-1610
0601-1105-1108-1117-1123-1302-A	1417	Mean System Maintenance Time	1610
0601-1105-1117-1123-1302-A	1418	Total Maintenance Time/Time Unit	1610
0601-1105-1117-1123-1302-A	1419	Maximum Corrective Maintenance Time	1610
0601-1105-1117-1123-1302	1420	Operational Availability (probability) (real)	1610
0601-1302-A	1421	Man Time Between Failure (MTBF)	1518-1610
1108	1422	System	1610
1109	1423	Subsystem	1610
1110	1424	Component	1610
1111	1425	Subcomponent	1610
1112	1426	Sub-subcomponent	1610
1113	1427	Part	1610

15 QQPRI

I.D. No.	Elements
1517	Number of Work Shifts
1518	Quality and Quantity of Personnel per Shift

16 TEPI

I.D. No.	Element
1610	Maintainability of Training Equipment

LEGEND:

A -- Data generated within a product (may be entirely new, or the result of the recombination of elements of forgoing products).

nn -- Indicates all data elements within any given product.

Fig. 8 Relationships among the elements of maintainability and its input and output elements.

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PHASE I. PLANNING	PHASE II. DESIGN		PHASE III. PRODUCTION		
PLANNING GROUPS	DESIGN ENGINEERS				
	CONFIGURATION	MAINTAINABILITY	MANNING	TRAINING	TECHNICAL PUBLICATIONS

06 PROCUREMENT SPECIFICATIONS

I.D. No.	Element
0612	Military Purpose

11 TASK ANALYSIS

I.D. No.	Elements
1101	Phase
1102	Phase Segment
1103	Function
1104	Job
1108	System
1109	Subsystems
1110	Components
1111	Subcomponents
1112	Sub-subcomponents
1113	Parts
1114	Job Location
1116	Tools, Equipment, Fixtures, Supplies Required
1117	Number of Personnel Required to Perform Task
1118	Hazards
1121	Skill Requirements
1122	Knowledge Requirements
1123	Time to Perform Task
1127	Personnel Classification
1128	Task Sharing Classification
1129	Machine Output
1133	Frequency of Task Performance
1134	Time-Line Information
1143	Performance Characteristics of Equipment
1145	Accuracy of Task Performance
1146	Reliability of Task Performance
1147	Mission/Function of Equipment

14 MAINTAINABILITY

I.D. No.	Elements
1403	Mean Time Between Maintenance Action
1405	Maintenance Man Hours/Operating Hour
1406	Maintenance Man Hours/Specific Maintenance Action
1408	Frequency of Preventive Maintenance
1415	Mean Corrective Maintenance Time
1416	Mean Preventive Maintenance Time
1421	Mean Time Between Failure

15 QQPRI

Input	I.D. No.	Elements	Output
B- 0612-B 1143 1109-1110-1111-1112-1113-1147 1110-1111-1112-A 1101-1108-1109-1110-1111-1112-1113 1110-1111-1112-A 1110-1111e1112-1129-A 1401-1102-1123-1134-A 1104-C 1103-1105-1123-1134-A 1105-1108-1109-1117-1121-1122-1123-1127-1128-A 1105-1108-1109-1117-1121-1122-1123-1127-1128-A 1105-1108-1109-1117-1121-1122-1123-1127-1128-A 1105-1114-1116-1123 1105-1114-1116-1117-1121-1122-1123-1127-1128-1133-B 1105-1114-1116-1117-1121-1122-1123-1127-1128-1133-1405-1406-1408 1105-1114-1116-1117-1121-1122-1123-1127-1128-1133-1145-1146-1403-1405-1406-1408-1415-1416-1421-A C 1105-1118-A	1501	Introduction	
	1502	Military Purpose	
	1503	Operational Characteristics	
	1504	Built-in Test Equipment	
	1505	Replaceable Assemblies	1822-1842
	1506	Probable Modes of Operation	
	1507	Expendable Components	1822-1842
	1508	Automatic Malfunction Indicators	1814-1821-1834-1841
	1509	Time-based Mission Segments	
	1510	Photographs to Illustrate Job Operations, Locations, Position	
	1511	Summary in Temporal Sequence of all Operator, Maintenance Control Function,	
	1512	Quality of Personnel	1606-1607
	1513	Quantity of Personnel	1606-1607
	1514	Team Performance	1815-1826-1835-1846
	1515	Time Location and Equipment Used for Each Task	1813-1820-1833-1840
	1516	Position Descriptions	
	1517	Number of Work Shifts	
	1518	Quality and Quantity of Personnel per Shift	
	1519	Organizational Diagrams	
	1520	Hazards Encountered and Solutions	

16 TEPI

I.D. No.	Elements
1606	Number of Persons to be Trained
1607	Number of Instructors Required

18 MAINTENANCE MANUAL

I.D. No.	Elements
1813	Equipment, Tools, Fixtures, Supplies Required to Perform Preventive Maintenance Actions
1814	Items to be Tested, Test Values, and the Actions and Equipment Required to Perform the Tests
1815	Job Crew Size
1820	Equipment, Tools, Fixtures, Supplies Required to Perform Corrective Maintenance Action
1821	Test Points, Test Values, and the Actions and Equipment Required to Perform the Tests
1822	Identification of Repairable and Expendable Items
1826	Job Crew Size
1833	Equipment, Tools, Fixtures, Supplies Required to Perform Preventive Maintenance Actions
1834	Items to be Tested, Test Values, and the Actions and Equipment Required to Perform the Tests
1835	Job Crew Size
1840	Equipment, Tools, Fixtures, Supplies Required to Perform Corrective Maintenance Action
1841	Test Points, Test Values, and the Actions and Equipment Required to Perform the Tests
1842	Identification of Repairable and Expendable Items
1846	Job Crew Size

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B -- Narrative information generated in response to report requirements.

C -- Data which are presented in the form of figures and tables.

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Fig. 9 Relationships among the elements of the QQPRI and its input and output elements.

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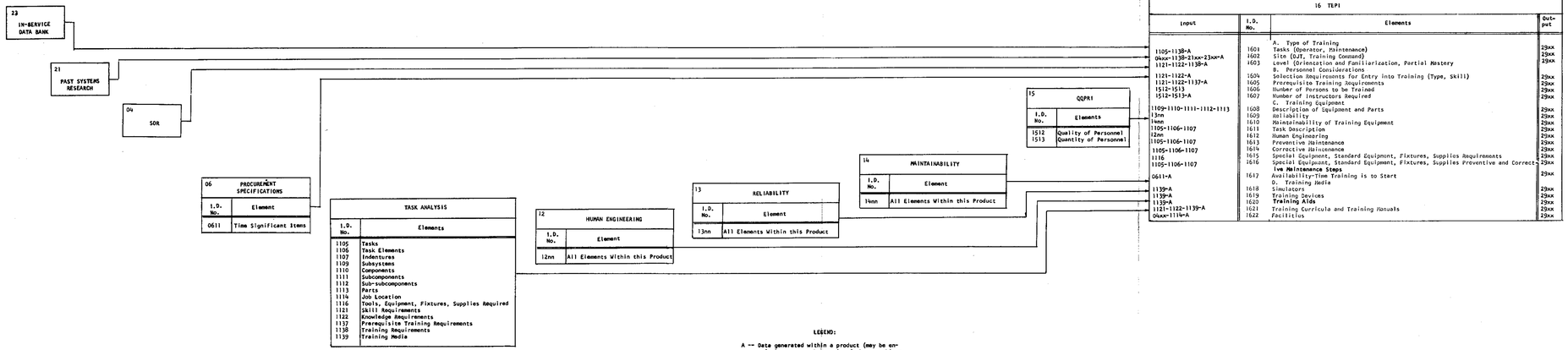
DEVELOPMENTAL PHASES →	PHASE I. PLANNING		PHASE II. DESIGN				PHASE III. PRODUCTION
GENERATORS →	DEVELOPMENT MANAGERS	PLANNING GROUPS	DESIGN ENGINEERS				
BASIC DATA SOURCES			CONFIGURATION	RELIABILITY	MAINTAINABILITY	MANNING	TRAINING



LEGEND:

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xx -- Substitute identification number for data element which has not been identified.

nn -- Indicates all data elements within any given product.

Fig. 10 Relationships among the elements of the TEPI and its input and output elements.

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DEVELOPMENTAL PHASES →	PHASE II. DESIGN		PHASE III. PRODUCTION
GENERATORS →	DESIGN ENGINEERS		
BASIC DATA SOURCES	CONFIGURATION	MANNING	TECHNICAL PUBLICATIONS

19 MILITARY SPECIFICATIONS AND REGULATIONS

10 SYSTEM ENGINEERING REPORTS

09 ENGINEERING DRAWINGS

11 TASK ANALYSIS

I.D. No.	Elements
1101	Phase
1102	Phase Segment
1104	Job
1105	Tasks
1106	Task Elements
1107	Indentures
1108	System
1109	Subsystems
1110	Components
1111	Subcomponents
1112	Sub-subcomponents
1113	Parts
1116	Tools, Equipment, Fixtures, Supplies Required
1117	Number of Personnel Required to Perform Task
1133	Frequency of Task Performance
1142	Equipment Number
1143	Performance Characteristics of Equipment

12 HUMAN ENGINEERING

I.D. No.	Element
1224	Safety Precautions and Emergency Procedures

15 QQPRI

I.D. No.	Elements
1505	Replaceable Assemblies
1507	Expendable Components
1508	Automatic Malfunction Indicators
1514	Team Performance
1515	Time, Location, and Equipment Used for Each Task

LEGEND:

A -- Data generated within a product (may be entirely new, or the result of the recombination of elements of foregoing products).

B -- Narrative information generated in response to report requirements.

C -- Data which are presented in the form of figures and tables.

xx -- Substitute identification number for data element which has not been defined.

18 MAINTENANCE MANUALS

Input	I.D. No.	Elements	Output
		A. Description of the System and its Parts	
1108-1109-1110-1111-1112-1113	1801	Names	31xx
1142	1802	Serial Numbers	31xx
09xx-B	1803	Physical Characteristics	31xx
1143-B	1804	Performance Characteristics	31xx
		B. Description of Auxiliary Equipment	
1108-1109-1110-1111-1112-1113-1116	1805	Names	31xx
1142	1806	Serial Numbers	31xx
09xx-B	1807	Physical Characteristics	31xx
1143-B	1808	Performance Characteristics	31xx
1105-1106-1107-A-B	1809	Equipment Operation	31xx
		C. Description of the System Preventive Maintenance Steps	
1105-1106-1107-1133-A	1810	Frequency	31xx
1101-1102-1108-1109-1110-1111-1112-1113	1811	Subsystems, Components, Parts to be Maintained	31xx
1105-1106-1107	1812	Preventive Maintenance Actions	31xx
1116-1515	1813	Equipment, Tools, Fixtures, Supplies Required to Perform Preventive Maintenance Actions	31xx
1105-1106-1107-1508-A	1814	Items to be Tested, Test Values, and the Actions and Equipment Required to Perform the Tests	31xx
1104-1105-1106-1107-1117-1514-A	1815	Job Crew Size	31xx
1104-1105-1106-1107-A	1816	Job Crew Duties	31xx
1224	1817	Safety Precautions	31xx
1224	1818	Emergency Procedures	31xx
		D. Description of the System Corrective Maintenance Steps	
1105-1106-1107	1819	Corrective Maintenance Actions	31xx
1116-1515	1820	Equipment, Tools, Fixtures, Supplies Required to Perform Corrective Maintenance Action	31xx
1105-1106-1107-1508-A	1821	Test Points, Test Values, and the Actions and Equipment Required to Perform the Tests	31xx
1505-1507	1822	Identification of Repairable, and Expendable Items	31xx
1105-1106-1107-A	1823	Maintenance Level at Which Corrective Action is to Take Place	31xx
1105-1106-1107-A	1824	Distribution of Repairable Items	31xx
10xx-19xx	1825	Procurement Instructions for Items Repaired at Another Maintenance Level for Expendable Items, and for Tools and Supplies	31xx
1104-1105-1106-1107-1117-1514-A	1826	Job Crew Size	31xx
1104-1105-1106-1107-A	1827	Job Crew Duties	31xx
1224	1828	Safety Precautions	31xx
1224	1829	Emergency Procedures	31xx
		E. Special Equipment, Standard Equipment, and Fixture Preventive Maintenance Steps	
1105-1106-1107-1133-A	1830	Frequency	31xx
1101-1102-1104-1109-1110-1111-1112-1113	1831	Components and Parts to be Maintained	31xx
1105-1106-1107	1832	Preventive Maintenance Actions	31xx
1116-1515	1833	Equipment Tools Fixtures, Supplies Required to Perform Preventive Maintenance Action	31xx
1105-1106-1107-1508-A	1834	Items to be Tested, Test Values, and the Actions and Equipment Required to Perform the Tests	31xx
1104-1105-1106-1107-1117-1514-A	1835	Job Crew Size	31xx
1104-1105-1106-1107-A	1836	Job Crew Duties	31xx
1224	1837	Safety Precautions	31xx
1224	1838	Emergency Procedures	31xx
		F. Special Equipment, Standard Equipment, Fixture Corrective Maintenance Steps	
1105-1106-1107	1839	Corrective Maintenance Actions	31xx
1116-1515	1840	Equipment, Tools, Fixtures, Supplies Required to Perform Corrective Maintenance Action	31xx
1105-1106-1107-1508-A	1841	Test Points, Test Values, and the Actions and Equipment Required to Perform the Tests	31xx
1505-1507	1842	Identification of Repairable and Expendable Items	31xx
1105-1106-1107-A	1843	Maintenance Level at Which Corrective Action is to Take Place	31xx
1105-1106-1107-A	1844	Distribution of Repairable Items	31xx
10xx-19xx	1845	Procurement Instructions for Items Repaired at Another Maintenance Level for Expendable Items, and for Tools and Supplies	31xx
1104-1105-1106-1107-1117-1514-A	1846	Job Crew Size	31xx
1104-1105-1106-1107-A	1847	Job Crew Duties	31xx
1224	1848	Safety Precautions	31xx
1224	1849	Emergency Procedures	31xx
17xx-A	1850	References for Additional Information	31xx
		F. Figural Information to Illustrate All of the Above	
C	1851	Tables	31xx
C	1852	Charts	31xx
C	1853	Drawings, Photographs	31xx
C	1854	Graphs	31xx

Fig. 11 Relationships among the elements of the maintenance manual and its input and output elements.

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APPENDIX II

DEFINITION OF DATA PRODUCTS AND ELEMENTS

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JOHN A. BOLDOVICI

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DEFINITION OF PRODUCTS AND ELEMENTS

Since it is impossible to obtain universal agreement on the content of specific products and elements, the following definitions are presented as guides to the interpretation of the hypothetical models shown in figures 1 through 11. The definition of each product is accompanied by its identifying number for rapid reference to the diagrams. The definitions are a composite of those found in Air Force Systems Command Manual 375-1 (ref 8), Air Force Regulation 38-8 (ref 9), and Air Force Systems Command Manual 80-3 (ref 10).

For purposes of categorizing the products in the phases of system development, the system life history was redefined in terms of the following three phases. These comprise the major column headings for all figures.

Planning. The activities which precede the decision to acquire a system. The term has meaning as a precise cut-off point, despite the large number of other concepts which define the activities in system development.

Design. As soon as a firm decision to produce a system has been made, the requirements for information change in that the detailed information necessary to produce hardware must be accumulated and /or generated. Immediate consideration must also be given to all the activities which must be developed concurrently with the hardware, e.g., training, personnel, plans for maintenance. That these activities must start with a commitment to purchase is quite clear, but termination of this phase is not as clear cut and shifts rather gradually to the third phase.

Production. Although it overlaps it in time, this phase differs from the design phase in that data generated are oriented toward system operation and related activities. Data produced in this phase assume the form they take in final outputs as far as the particular system is concerned.

The data categorized in these three groups overlap to some degree in both form and content, but the categories are sufficiently exclusive to make them useful in organizing a data classification system.

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The results of the generation of data may be viewed as products, with each product as the sum of other data units and available for use in generating other products. These products may be further subdivided into three classes which correspond to the three phases of the system life cycle, i.e., planning products, design products, and final operational products.

Shown under their related "generator" column headings in Figure 1 are the following planning and design products:

01. Initial Idea. The initial idea refers to the first conception of the weapon system. It is a relatively independent data source which at this point is unrelated to any other system. As soon as an attempt is made to relate other information to the initial idea, or to define the idea further, it becomes a new human factors data product. The initial idea contains only very general notions of the mission and performance characteristics of the weapon system. These notions become more detailed as they are related to other systems and past research.

02. System Requirements. Given the generation of an idea for a new weapon system, the general performance and mission requirements are then set forth in the system requirements. Although the information generated at this stage is very general, an attempt is usually made to define the requirements of the weapon system as fully as possible.

03. Functional Analysis for Planning. This analysis is a tracing of the weapon system from design through operation to its eventual "phase-out." In so doing, first estimates of the personnel and facilities requirements for the system are obtained.

04. Specific Operational Requirements. The specific operational requirement is one of the first official weapon system documents, and marks the first separate funding of the system. The physical and performance requirements for the system are defined as fully as possible, ancillary equipment and facility requirements are defined in general terms, and manning and training needs are considered.

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05. Specific Operational Requirement Study Reports. For requirements which seem to exceed the limitations of the current state-of-the art, studies are conducted in order to determine the feasibility of the requirements. The results of these studies are reported in the specific operational requirement study report.

06. Procurement Specifications. The procurement specifications are written in order to present a general description of the weapon system to contractors for bids. The specifications define as specifically as possible all of the physical and performance characteristics for the weapon system and its ancillary equipment. The facility requirements and maintenance philosophy are delineated, and the personnel and training requirements are defined.

07. Request for Proposal. The request for proposal identifies the physical and performance characteristics for the weapon system, and defines for prospective contractors the needs and expectations of the procuring activity.

08. Contract. The contract is a binding agreement between the contractor of the weapon system and the Government. It sets forth the hardware and ancillary equipment, materials, and supplies that the contractor is expected to provide, and defines the quality and quantity of that which is to be provided.

09. Engineering Drawings. Although engineering drawings are not human factors data per se, they are used by human factors people to evaluate man-machine relations before the hardware is built. Engineering drawings may be viewed as the most detailed weapon system data, owing to the specificity of the hardware dimensions and configurations which they present.

10. System Engineering Reports. System engineering reports present the results of basic engineering studies required for hardware development.

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11. Task Analysis. Task analyses contain the most detailed human factors data, and are analyses of the tasks required by personnel to operate and maintain the weapon system and its associated equipment. For this report the task analysis was used as a focal point in the presentation of human factors task data. Although the content of the analysis may vary as a function of the generator, the task analysis provides a broad framework in which all human factors data can be categorized. The task analysis format presented by Reed, Foley, Graham, & Hilgeman, (ref 6) was modified and adopted for this report as it seemed to provide a sufficient level of detail for the presentation of human factors task data.

The categories within task analysis are the elements of information common to most or many of the products. The last two digits of the numbers associated with the elements in the following list are the elements' identification numbers.

1101. & 1102. Phase and Phase Segments. The phase of a weapon system describes the system at a given point in its life cycle. Phase segments describe more specific areas of each phase. The phases and phase segments within a system life cycle are given on page 27.

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Phases and Phase Segments

Phase Number	Title
1	Weapon System Definition
	a. Origin
	b. Developmental Managing
	c. Planning
2	Design Engineering
	a. Configuration
	b. Reliability
	c. Maintainability
	d. Manning
	e. Training
	f. Technical Publications
3	Weapon System Delivery
4	Receipt/Storage/Issue
	a. Testing
	b. Preparing
	c. Distributing
5	Mission Operation
	a. Readying
	b. Take-off
	c. Rendevous
	d. Attack Flight
	e. Attack
	f. Return Flight
	g. Landing
6	Maintenance
	a. Organizational
	(1) Preventive
	(2) Corrective
	b. Intermediate
	(1) Preventive
	(2) Corrective
	c. Depot
7	Phase-out

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1103. Function. Functions describe the purpose which tasks are to serve, and usually take the form of a behavioral verb such as "installing" or "checking." A behavioral verb is contrasted with a movement verb in that the former might denote a group of movements while the latter is a more detailed verb used in defining a task or task element. Examples of movement verbs are "detect," "identify," "align." The exact number of verbs which belong to each category is at this time unknown, but the total number of possible behavioral classes is very large.

1104. Job. A job is a group of tasks which make up an operator or maintenance unit.

1105. Task. A task is a portion of a job and is a movement unit. It is the central aspect in the task analysis to which all else relates. It consists of a movement verb and an object. There are approximately 170 movement verbs. Objects can be grouped into three classes, and the total number of objects approximately equals the total number of subcomponents or sub-sub-components in a weapon system.

1106. & 1107. Task Elements and Indentures. Task elements and indentures are smaller units of a task and are required where tasks involve a sequence of steps. Their form is similar to a task, and thus, the number of subcategories required to account for tasks also applies here.

1108. System. A system may be viewed as related pieces of hardware which are designed collectively to fulfill a specific mission. For example, a particular jet aircraft system includes the fighter, the tanker required for in-flight refueling, and the associated ground equipment.

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1109. Subsystem. A subsystem is one part of a system such as the fighter or tanker cited above. Subsystems may be further subdivided into sub-subsystems; e.g., cockpit or landing gears.

1110. Component. A component is a smaller self-contained unit, usually consisting of several parts, and as a unit it has a certain degree of functional completeness.

1111. & 1112. Subcomponent and Sub-subcomponent. Subcomponents and sub-subcomponents are self-contained units within components, and may perform operations which are functional units.

1113. Part. A part is the smallest hardware unit.

1114. Job Location. The job location describes where the job takes place.

1115. Frequency of Job Performance. Frequency of job performance refers to the number of times per given unit of time that a job must be performed.

1116. Tools, Equipment, Fixtures Supplies Required. This category describes all of the tools, equipment, fixtures and supplies that are required to perform each task.

1117. Number of Personnel Required to Perform Task. The minimum number of persons that are required to perform a task is described by this category which usually does not exceed a two-digit number.

1118. Hazard. Hazards are sources of possible bodily injury.

1119. Communication. Communication is the transmission of information from one human being to another. Communication is identified by (1) type of transmission: input or output; (2) method: oral, written, graphical, or gesture; and (3) characteristics; rate and duration.

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1120. Difficulty Index. The difficulty index is a rating of the task based upon the knowledge and skill required for its performance, and is usually a one-digit number.

1121. Skill Requirements. Unique or special aptitudes required to perform the task are identified by the skill requirements.

1122. Knowledge Requirements. Qualitative estimates of the knowledge required to perform the task are listed in this category.

1123. Time to Perform Task. The time required to perform the task is recorded in this category to two decimal places.

1124. Source of Information. The source of the information being analyzed is entered in this category; and the category can be subdivided into (1) industry, (2) Government agencies, (3) universities, and (4) other.

1125. Date of Information. This category indicates the date on which the information which is being analyzed was prepared.

1126. Information Revision Index. There is a need to know when and how many times the information has been revised, and this category would give such an indication.

1127. Personnel Classification. The type of personnel required to perform the task is indicated in this category. During the early parts of system development this might consist of a general description of the type of personnel required, while exact AFSC's or DOD classification might be listed during later revisions.

1128. Task Sharing Classification. If more than one person is required to perform a task, this category indicates the types of personnel which are required to assist in performing the task.

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1129. Machine Output. Machine outputs are those outputs of machines which impinge upon man's sensorium, and are classified according to the receptors with which they are associated: (1) visual (see Appendix for subcategories under this subelement), (2) auditory, (3) tactual, (4) proprioceptive, (5) vestibular, (6) somatesthetic, (7) olfactory, (8) nociceptive, and (9) thermal. Sensory information has been studied extensively and is, consequently, well defined. The result is that a detailed classification of any one of the sensory systems yields a large volume of classes.

1130. Human Output. Human outputs are control and non-control activities required by man in order to react to machine outputs. Human outputs are classified as to the types of controls, the characteristics of the controls, the body member used, and non-control activities.

1131. Psychological Processes. Psychological processes could also be termed behavioral processes, or observable measures of behavior. Subclasses under this category are: (1) auditory-vocal processes, (2) motor processes, (3) visual processes, (4) coordination processes, (5) tactual processes, (6) decision-making processes, and (7) symbolic data operations. These subclasses may be further subdivided into types, criterion measures, and performance measures.

1132. Task Criticality. The criticality of the task is an index of the possible effects which improper performance of the task would have upon various aspects of the system; e.g., mission success, personnel safety, subsystem performance. Each task is given a rating or series of ratings along a five-point scale, and the rating serves as the index of criticality.

1133. Frequency of Task Performance. The frequency of task performance is indicated by functional units of the system, such as mission, mission phase, and work shift and by time periods; e.g., number of times per month, week, hour.

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1134. Time-Line Information. Time-line information gives an indication of temporal relations among tasks.

1135. Time Criticality. This category gives an indication of whether or not the performance of the task within the time requirements is critical to the successful performance of the task.

1136. Task Area Environment. Identified in this category are the environmental factors which affect task performance. Environmental factors are subclassified by type in the following manner: (1) physical, (2) psychological, (3) physiological, and (4) movement restraints. Each of these subclasses may be further subdivided by type and characteristics.

1137. Prerequisite Training Requirements. This category lists the training requirements necessary before a person can perform a particular job. Two broad classes of training, general and specialized, are listed.

1138. Training Requirements. In order for personnel to perform a job satisfactorily, it is necessary to train them to an initial level of proficiency. This category lists the necessary training requirements by type of training, level of proficiency required, and length of training.

1139. Training Media. The means by which the needed information is transmitted to the trainees are listed in this category by types and numbers.

1140. Training Equipment Characteristics. This category identifies, by function, the characteristics of the training equipment.

1141. Hardware Status. This category indicates the phase of system development in which a given piece of system hardware is included.

1142. Equipment Number. Each piece of equipment, component, or part is identified by a number.

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1143. Performance Characteristics of Equipment. The functional performance characteristics of equipment, components, and parts are identified in this category. The subcategories consist of such items as speed and altitude.

1144. Cost. The cost of production, procurement, operation, and maintenance for each piece of hardware is identified in this category.

1145. Accuracy of Task Performance. The probability of error in performing each task is represented in this category.

1146. Reliability of Task Performance. This category identifies the reliability of the accuracy and performance time measures obtained for each task.

1147. Mission/Function of Hardware. This category identifies the action for which each piece of hardware is designed.

1148. Task Prerequisites. Any action which must be performed before a given task can be performed is identified in this category.

12. Human Engineering. This product is concerned with "the design of equipment and the arranging of the physical conditions of work in relation to human sensory capacities, psychomotor abilities, learning capacities, body dimensions, comfort, safety, and satisfactions" (ref 2). Data categories within this product are (1) machine output, (2) human output, (3) psychological processes, (4) task area environment, (5) safety precautions and emergency procedures, (6) hardware description, and (7) performance description. Much of the information in the human engineering product is the same as, or similar to, that which appears in the task analysis.

13. Reliability. This product reports the accuracy and dependability with which the system hardware will perform.

14. Maintainability. The maintenance philosophy and preventive and corrective maintenance requirements for all of the system hardware are identified in this product.

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15. Qualitative and Quantitative Personnel Requirements Information (QQPRI). This product identifies the types and quantities of personnel required to operate, control, and maintain the weapon system.

16. Training Equipment Planning Information (TEPI). The information required to develop the required training equipment is identified in this product. The categories comprising this product are (1) type of training, (2) personnel considerations, (3) training equipment, (4) training media, and (5) training facilities. Many of the categories are the same as or similar to those appearing in the task analysis, and much of the information in this category is taken directly from the task analysis.

17. Personnel/Equipment Data (PED). "PED is centrally controlled analytical data in the form of task and equipment information. It defines the relationship between system personnel and system hardware, other personnel subsystem elements and the technical data requirements of AFR 310-1" (ref 9).

18. Maintenance Manual. A maintenance manual is a technical publication which sets forth, in detail, the preventive and corrective maintenance which is to be performed on the system hardware. The categories which comprise the maintenance manual are (1) description of the system and its parts; (2) description of auxiliary equipment; (3) description of the system preventive maintenance steps; (4) description of the system corrective maintenance steps; (5) special equipment, standard equipment, and fixture preventive maintenance steps; (6) special equipment, standard equipment, and fixtures corrective maintenance steps; (7) references for additional information; and (8) related figural information.

19. Military Specifications and Regulations. All of the military documents which establish planning, guidance, and policy, and which set forth human factors requirements have been grouped into this product. These documents are used by development managers, planning groups, and design engineers as guides which define their efforts toward developing the final operational system.

20. Research Reports. Research reports are a group of documents which are usually generated in order to satisfy a specific

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need. These are usually bound independently and contain a wide variety of information, serving as sources of data for the development of new weapon systems.

21. Past Systems Research. Past systems research is that body of human factors information which has been generated in the course of developing operational weapon systems. This product may also include information which is generated for systems which are not funded, and therefore, not developed.

22. Professional Journals. Professional journals are regularly and periodically published documents which bind together information which is topically similar.

23. In-Service Data Bank. An in-service data bank is a centralized store of data which is available to military and related users only. The data bank may be computerized or it may be a library or filing system for receiving, storing, and distributing information.

24. Common Data Bank. A common data bank is a centralized store of data which is usually available to a virtually unlimited number of users; e.g., the Bureau of Statistics and the Library of Congress.

25. Handbook Data. Handbook data are comprised of a body of tabularly grouped data which have been accumulated over a long period of time. Although handbooks usually contain data which are narrower in range than journals, the information is generalizable over a broad range of performance requirements. Included in this product are some military specifications which have been published as design guides.

26. Textbooks. Textbooks are books which have been written for resource and teaching purposes. They represent an attempt to describe fully the information within a limited field of knowledge.

27. Hardware. The operational equipment designed and built to accomplish the primary mission of the system.

28. Personnel. The trained personnel required to operate and maintain the equipment designed to accomplish the primary mission of the system.

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29. Training. The programs designed to train personnel who provide initial and continuing manning for the efficient operation of the system.

30. Facilities. Equipment and installations other than operational hardware which is required to support operational equipment in accomplishment of the primary mission.

31. Technical Publications. Those documents required to implement and continue operations of the equipment in accomplishment of the primary operation of the system.

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APPENDIX III

CATEGORIES* ASSOCIATED WITH DATA ELEMENT—

"MACHINE OUTPUT, VISUAL"

L. DUNCAN HANNAH

RAYMOND C. MANION

*The categories were derived from information reported by Baker and Grether (ref 1), Morgan, et al (ref 4), Handbook of Human Engineering Data (ref 7), Woodson (ref 12), and Reed, et al (ref 6).

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11. Task Analysis

29 Machine Output

01 Visual

1 Applications
1 Printed Materials
1 Print Characteristics
1 Height
2 Width
3 Line Width
4 Face Type
1 Antique
2 Cheltenham
3 American Typewriter
4 Cloister Black
5 Bodoni
6 Garamont
7 Old Style
8 Caslon Old Style
9 Kabel Light
10 Scotch Roman
5 Case
1 Upper
2 Lower
6 Point
7 Pica
2 Contrast
1 Hue Contrast
2 Brightness

3 Spatial Relations
1 Between Letters
2 Between Words
3 Between Columns
4 Between Word Groups
5 Left Margin
6 Right Margin
7 Top Margin
8 Bottom Margin
4 Content
1 Number
2 Letter

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3 Word
4 Line
5 Abbreviation
6 Symbol
5 Subjective Evaluation
1 Visibility
1 Percent Difference
2 Rank
3 Distance
2 Perceptibility
1 Percent Difference
2 Rank
3 Distance
3 Speed of Reading
1 Percent Difference
2 Rank
3 Distance
4 Reader Opinion of Relative Legibility
1 Mean
2 Rank
6 Printed Material Types
1 Book
2 Pamphlet
3 Instruction Card
4 Charts
5 Graphs
6 Decals
7 Check Lists
8 Labels
2 Cathode Ray Tubes
1 Type
1 Radar
2 Sonar
3 Oscilloscope
4 Mapping
5 Tracker
6 Television
7 Overhead Display
2 Shape
1 Rectangular
1 Length
2 Width

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- 2 Circular
  - 1 Radius
- 3 Size
  - 1 Range
  - 2 Target Size
    - 1 Beam Width
    - 2 Pulse Length
  - 3 Constant
  - 4 Equation/Range/Target/Size
- 4 Types of Presentation
  - 1 A-Scan
  - 2 B-Scan
  - 3 C-Scan
  - 4 F-Scan
  - 5 PPI-Scan
  - 6 Sector Scan
  - 7 Alphanumeric
  - 8 Symbolic
  - 9 Transformed Data
  - 10 Video
- 5 Visibility
  - 1 Visual Angle of Signal
  - 2 Brightness of Background
  - 3 Signal Duration
  - 4 Visual-Adaptation Level
    - 1 Pre-Exposure Brightness
    - 2 Time to Detect Target
  - 5 Viewing Distance
  - 6 Brightness of Signal
  - 7 Workplace Brightness
  - 8 Glare
    - 1 Direct
    - 2 Specular
  - 9 Resolution
- 6 Design Factors
  - 1 Signal Size
    - 1 Beam Width
    - 2 Pulse Length
  - 2 Scope Brightness
  - 3 Scope Brightness Adjustment
  - 4 Contrast Direction
  - 5 Scope Brightness Distribution
- 7 Evaluation
  - 1 Time Required
  - 2 Errors

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8 Range Indication
  1 Polar Coordinate
    1 Mark Interval
    2 Numbering System
    3 Ring Separation Distance
    4 Coding System
    5 Reading Aids
      1 Cursor
      2 Pantograph
      3 Overlay
    6 Automatic Input
9 Bearing Indication
  1 Reading Aids
    1 Dial and Cursor
    2 Counter and Cursor
    3 Dial Estimate
    4 Pantograph
    5 Overlay of Radial Lines
10 Three Coordinate Information Display
  1 Coding
    1 Type of Information
      1 Friend or Foe
      2 Type of Target
        1 Missile
        2 Bomber
        3 Fighter
        4 Interceptor
      3 Speed and Course of Target
      4 Altitude of Target
    2 Method
      1 Color
      2 Shape
      3 Size
      4 Visual Number
      5 Line Length
      6 Angular Orientation
      7 Brightness
      8 Flash Rate
      9 Stereo- Depth
    3 Evaluation
      1 Number of Categories Available
      2 Error Rate
      3 Operator Fatigue, Distractability, Interference
      4 Space Requirements

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- 11 Methods of Use
  - 1 Tactical Evaluation
  - 2 Fire Direction
  - 3 Air Traffic Control
  - 4 Navigation
  - 5 Bombing
- 3 Mechanical Indicators
  - 1 Types
    - 1 Symbolic
      - 1 Types
        - 1 Direct-Reading
        - 2 Moving Pointer with Fixed Scale
        - 3 Moving Scale with Fixed Pointer
        - 4 Liquid Column Instrument
        - 5 Circular and Curved Scale with Moving Pointer
        - 6 Vertical and Horizontal Straight Scale with Moving Pointer
        - 7 Circular and Curver Scale with Fixed Pointer
        - 8 Vertical and Horizontal Straight Scale with Fixed Pointer
        - 9 Rotary Selection Switch
        - 10 Slide Rule
      - 2 Methods of Use
        - 1 Quantitative Reading
        - 2 Qualitative Reading
        - 3 Check Reading
        - 4 Setting
        - 5 Tracking
    - 2 Pictorial
      - 1 Types
        - 1 Component Position
        - 2 Attitude
        - 3 Curve Rate
        - 4 Pointer
        - 5 Self/Environmental Reference
        - 6 Cross Pointer
        - 7 Heading
      - 2 Methods of Use
        - 1 Flight Instruments
        - 2 Navigation Instrume nts
      - 3 Long Scale
        - 1 Types
          - 1 Multiple Pointer
          - 2 Subdial

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- 3 Direct- eading Counter
- 4 Sensitive Pointer-Moving Scale Combination
- 5 Sensitive Pointer-Counter
- 6 Moving-Pointer-Moving-Scale
- 7 Moving-Pointer-Counter
- 8 Moving-Tape with Fixed Index

2 Conditions of Use

- 1 Reading Distance
- 2 Angle of View
- 3 Illumination
- 4 Presence of Other Instruments
- 5 Location and Method of Actuation of Related Controls
- 6 Background Illumination
- 7 Constraints
  - 1 Dark Adaptation
  - 2 Past Indicator Type
  - 3 Precision Required
- 8 Space Requirements

3 Design

- 1 Counter Design
  - 1 Motion
    - 1 Snap
    - 2 Continuous
  - 2 Rotation Direction of Controls
- 2 Scale Design
  - 1 Scale Range
  - 2 Numbered Interval Value
  - 3 Graduation Interval Value
  - 4 Graduation Mark Indication
    - 1 Major
    - 2 Minor
    - 3 Intermediate
  - 5 Transformed Scale Values
  - 6 Non-Linear Scale
    - 1 Height
    - 2 Width
    - 3 Separation
- 3 Instrument Zone Markings
  - 1 Coding Methods
    - 1 Color
    - 2 Shape
- 4 Pointer Design
  - 1 Length
  - 2 Height from Face

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3 Color
4 Shape
5 Point Angle
5 Instrument Identification
1 Name Plate Labels
2 Position
3 Size
4 Shape
5 Color
6 Unique Configuration
6 Numerals and Letters
1 Numeral Style
1 Style
2 Height
3 Width
4 Separation
2 Letter Style
1 Style
2 Height
3 Width
4 Separation
4 Printed Material
5 Evaluation
1 Advantages
2 Disadvantages
3 Errors
4 Time
4 Warning and Signal Devices
1 Types
1 Warning
1 Methods of Use
1 Attention Getting
2 Location
3 Brightness
4 Identification
1 Size
2 Grouping
3 Labeling
4 Color
5 Coding
5 Flash Rate
6 Flash Duration
2 Caution
1 Master Caution Light
1 Location
2 Brightness
3 Identification

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- 2 Auxiliary Panel
  - 1 Location
  - 2 Identification
- 3 Mechanical "Flag" Signals
  - 1 Location
  - 2 Brightness
  - 3 Identification

2 Evaluation
- 1 Errors
- 2 Time

5 Coding

1 Methods
- 1 Color
- 2 Number of Dots
- 3 Brightness
- 4 Shape
- 5 Orientation
- 6 Flash Rate
- 7 Size
- 8 Length of Line
- 9 Stereo-Depth

2 Evaluation
- 1 Time
- 2 Errors

6 Workplace Illumination

1 General Workplace
- 1 Illumination Level
- 2 Light Distribution
  - 1 Direct
  - 2 Indirect
  - 3 Diffuse
- 3 Glare
  - 1 Direct
  - 2 Specular
- 4 Surround Brightness
- 5 Illuminate Type
  - 1 Tungsten-Filament Incandescent
  - 2 Mercury Arc
  - 3 Sodium Vapor
  - 4 Fluorescent Luminaires
- 6 Surface Reflectance
  - 1 Diffuse
  - 2 Specular
  - 3 Compound

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7 Color
2 Instrument and Control Console
1 Dark Adaptation
1 Pre-Exposure Brightness
2 Time in the Dark
3 Sensitivity Required
2 Reflection
3 Brightness
1 Surround Brightness
2 Control Brightness
4 Uniformity of Light Distribution
5 Special Lighting Conditions
1 Lighting Flashes
2 Search Lights
3 Rocket and Gun Flashes
4 Simulated Daytime Instrument Flight
5 Chart Reading
6 Lighting Systems
1 Flood
2 Indirect
3 Edge
4 Rear
3 Radar Room
1 Cross-Polarization System
2 Broad-Band-Blue System
3 Yellow-Minus-Red-System
4 Mercury- Minus -Red-System
4 Evaluation
1 Advantage
2 Disadvantage
3 Error
4 Time
7 Detection, Identification, Estimation
1 Visual Acuity
1 Minimum Perceptible Acuity
1 Visual Angle
2 Brightness
3 Background Illumination
4 Contrast
5 Distance
2 Minimum Separable Acuity
1 Visual Angle
2 Brightness

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3 Background Illumination
4 Contrast
5 Distance

3 Vernier Acuity
1 Visual Angle
2 Brightness
3 Background Illumination
4 Contrast
5 Distance

4 Stereoscopic Acuity
1 Visual Angle
2 Brightness
3 Background Illumination
4 Contrast
5 Distance

5 Retinal Location
1 Visual Angle
2 Degrees Temporally from Fovea
3 Brightness
4 Background Illumination
5 Contrast
6 Distance

6 Glare

7 Color of Illuminant
1 Visual Angle
2 Brightness
3 Background Illumination
4 Contrast
5 Distance
6 Color
7 Frequency

8 Non-Uniform Background

9 Pattern Recognition
1 Visual Angle
2 Brightness
3 Background Illumination
4 Contrast
5 Distance
6 Recognition

10 Pattern Identification
1 Visual Angle
2 Brightness
3 Background Illumination
4 Contrast

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5 Distance
6 Identification

11 Magnification Aids
1 Brightness Reduction
2 Contrast Ratio Reduction
3 Image Sharpness
4 Target Movement
5 Movement of Optics
6 Field of View

12 Size Estimation
1 Visual Angle
2 Brightness
3 Background Illumination
4 Contrast
5 Distance
6 Accuracy

13 Range Estimation
1 Visual Angle
2 Brightness
3 Background Illumination
4 Contrast
5 Distance
6 Accuracy

14 Velocity Estimation
1 Visual Angle
2 Brightness
3 Background Illumination
4 Contrast
5 Distance
6 Accuracy

15 Acceleration Estimation
1 Visual Angle
2 Brightness
3 Background Illumination
4 Contrast
5 Distance
6 Accuracy

16 Complex Displays
1 Visual Angle
2 Display Clutter
3 Resolution

17 Evaluation
1 Time
2 Error

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8 Displays
1 Types
1 Symbolic
2 Pictorial
2 Conditions of Use
1 Viewing Distance
2 Illumination
3 Viewing Angle
4 Consistency of Presentation
5 Compatibility
3 Methods of Use
1 Quantitative Reading
2 Qualitative Reading
3 Check Reading
4 Setting
5 Tracking
6 Spatial Orientation
4 Combination and Integration of Displays
1 Related Kinds of Information
2 First Derivatives
3 Separate Values
9 Instrument Panel Layout
1 Instrument Priority
2 Position
3 Viewing Angle
4 Distance
5 Horizontal and Vertical Separation
1 Horizontal
2 Vertical
6 Position of Adjusting Knobs and Switches
1 Position
2 Control-Indicator Movement
7 Arrangement
1 Grouping
2 Position
8 Combination of Instruments
1 Combined Information
2 Advantages
3 Disadvantages

2 Characteristics
1 Light Sensitivity
1 Characteristics of the Subject
1 Age
2 Sex

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2 Characteristics of the Eye
1 Region of the Retina Stimulated
2 Mode of Use
1 Monocular
2 Binocular
3 Characteristics of the Stimulus
1 Duration of Previous Light
2 Intensity of Previous Light
3 Color of Previous Light
4 Color of Measuring Light
5 Size of Test Surface
6 Type of Test Surface
4 Physiological Condition of the Organism
1 Oxygen Level
2 Vitamin A Level
3 Blood Sugar Level

2 Brightness Discrimination
1 Stimulus Size
2 Stimulus Shape
3 Duration of Exposure
4 Stimulus Brightness
5 Surround Brightness
6 Frequency
7 Distance Between Stimuli
8 Retinal Area Stimulated

3 Visual Acuity
1 Factors Commonly Measured
1 Retinal Resolution
2 Lens Accommodation
3 Form Perception
4 Resistance to Interference
2 Types of Acuity
1 Minimum Perceptible
2 Minimum Separable
3 Minimum Distinguishable
4 Minimum Cognoscible
3 Measurement Parameters
1 Visual Angle
2 Speed of Response
3 Hue
4 Brightness
5 Saturation
6 Distance
7 Duration of Exposure
8 Region of Retina Stimulated

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4 Depth Perception
  1 Types
    1 Real Depth
    2 Apparent Depth
  2 Measurement Parameters
    1 Size
    2 Brightness
    3 Distance
  3 Physiological Factors
    1 Retinal Disparity
    2 Accommodation
    3 Convergence
    4 Binocular
    5 Monocular
    6 Speed of Adjustment
      1 Fatigue
      2 Age
  4 External Cues
    1 Interception
    2 Shadows
    3 Distribution of Illumination
    4 Horizon Line
    5 Pattern Differentiation
    6 Relative Movement
    7 Aerial Perspective
  5 Psychophysiological Variables
    1 Oxygen Level
    2 Illumination
    3 Pupil Size
    4 Metrazol
    5 Exercise
    6 Hyperventilation
    7 Blood Sugar Variations
    8 Posture
5 Color Vision
  1 Measurement Parameters
    1 Hue
    2 Brightness
    3 Saturation
  2 Color Phenomena
    1 Constancy
    2 Adaptation
    3 Contrast
    4 After-Images
    5 Color Blindness
    6 Retinal Color Zones

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6 Intermittent Stimulation
- 1 Critical Fusion Frequency
- 2 Factors Influencing CFF
  - 1 Individual Differences
    - 1 Age
    - 2 Condition of Fatigue
    - 3 Set
  - 2 Stimulus Brightness
  - 3 Stimulus Size
  - 4 Color
  - 5 Light-Dark Ratio
  - 6 Exposure Time
  - 7 Surround Brightness
  - 8 Region of Retina Stimulated

7 Perception of Movement
- 1 Types
  - 1 Objective
  - 2 Subjective
    - 1 Stroboscopic
    - 2 Illusory
- 2 Gradations of Objective Movement
  - 1 Infra-Perceptible
  - 2 Perceptible
    - 1 Slow
    - 2 Medium
    - 3 Fast
  - 3 Supra-Perceptible
- 3 Variables Influencing Movement Threshold Values
  - 1 Velocity
  - 2 Path of Movement
  - 3 Distance
  - 4 Duration
  - 5 Stimulus Size
  - 6 Stimulus Shape
  - 7 Field Size
  - 8 Illumination
  - 9 Retinal Area
  - 10 Monocular/Binocular
  - 11 Eye Movements
- 4 Variables Affecting Stroboscopic Movement
  - 1 Temporal-Spatial
    - 1 Time Interval Between Stimuli
    - 2 Exposure Time
    - 3 Distance Between Stimuli
    - 4 Configuration

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2 Intensity
3 Character of Stimulus
  1 Similarity
4 Observational Attitude

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REFERENCES

1. Baker, C. A., and W. F. Grether, Visual Presentation of Information, WADC-TR 54-160, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, August 1954 (AD 43 064).

2. English, H. B., and A. C. English, A Comprehensive Dictionary of Psychological and Psychoanalytical Terms, Longmans, Green and Co., Inc., New York, New York, 1958.

3. Hannah, L. D., J. A. Boldovici, J. W. Altman, and R. C. Manion, The Role of Human Factors Task Data in Aerospace System Design and Development, AMRL-TR-65-131, Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio, August 1965.

4. Morgan, C. T., J. S. Cook, III, A. Chapanis, and M. W. Lund, Human Engineering Guide to Equipment Design, McGraw-Hill Book Co., Inc., New York, New York, 1963.

5. National Aeronautics and Space Administration, Apollo Program Configuration Management Manual, NPC 500-1, Manned Spacecraft Center, Houston, Texas.

6. Reed, L. E., J. P. Foley, Jr., R. S. Graham, and J. B. Hilgeman, A Methodological Approach to the Analysis and Automatic Handling of Task Information for Systems in the Conceptual Phase, AMRL-TDR-63-78, Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio, August 1963 (AD 419 018).

7. Tufts College, Handbook of Human Engineering Data, Tufts College, Medford, Mass., 1952 (AD 43 650 and AD 85 211).

8. United States Air Force, Configuration Management During Definition and Acquisition Phases, AFSCM 375-1, Air Force Systems Command, Andrews Air Force Base, Washington, D. C., 1 June 1964.

9. United States Air Force, Development of a Personnel Subsystem for Aerospace Systems, AFR 30-8, Department of the Air Force, Washington, D. C., 16 October 1964.

10. United States Air Force, Handbook of Instructions for Aerospace Personnal Subsystem Designers, AFSCM 80-3, Air Force Systems Command, Andrews Air Force Base, Washington, D. C., 15 April 1964.

11. United States Air Force, System Engineering Management Procedures, AFSCM 375-5, Air Force Systems Command, Andrews Air Force Base, Washington, D. C., 14 December 1964.

12. Woodson, W. E., Human Engineering Guide for Equipment Designers, University of California Press, Berkeley, California, 1954.

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13. ABSTRACT The generation, use, and flow of human factors task data in aerospace system design and development are described. The data are characterized by a process of continual transformation in content and form of presentation occurring throughout the iterative cycles of system development. The networks within which data flow are shown to be extensive in size, pervasive in nature, and complex in their dynamic relationships. These dynamic processes are illustrated in flow diagrams showing the relationships of human factors task data and their input/output elements in functional analysis for planning, specifications, task analysis, human engineering, reliability, maintainability, qualitative and quantitative personnel requirements information, training equipment planning information, and maintenance manuals.

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