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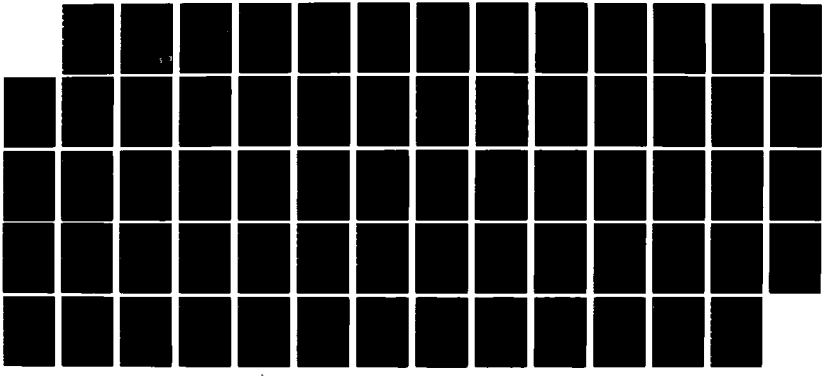

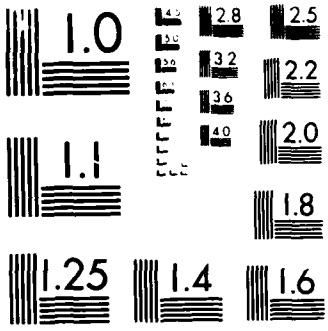
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MANAGEMENT CONSULTING & RESEARCH, INC.

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LONG RANGE ENLISTED MANPOWER REQUIREMENTS ESTIMATION

By

William P. Hutzler
Patricia A. Insley

29 May 1985

Prepared For:

Office of the Assistant Secretary of Defense
for Manpower, Installations and Logistics

Contract Number: MDA903-82-C-0400

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PREFACE

Management Consulting & Research, Inc. (MCR) has been tasked by the Office of the Assistant Secretary of Defense for Manpower, Installations and Logistics, OASD (MI&L), under contract MDA903-82-C-0400, to perform a multi-phase research effort. To date, MCR's work on this project has resulted in:

- development and demonstration of a methodology for projecting the long-term supply of manpower, by categories of aptitude, in the non-prior service youth population;
- design and demonstration of a procedure for determining, very early in the acquisition process, manpower demand over the life cycle of an individual weapon system; and
- recommendation of a procedure for integrating long-range manpower demand projections across individual weapon systems and across Services.

Implementation of these manpower supply and demand methodologies is intended to provide the Department of Defense with a means of identifying probable weapon system manning constraints while systems are still in the earliest stages of their acquisition planning.

This report addresses the third item above and is the Task VI deliverable for this contract. The procedure that is recommended here is one that will aid long-range manpower planning in several ways. On implementing the recommended method, planners will be able to make projections of Service-wide and DoD-wide manpower requirements for operator and below depot-level maintenance personnel. It will be possible to include in these projections consideration of weapon systems that are very early in

the acquisition process at the time the projections are made. The projections themselves will enable manpower planners and weapon system designers to account for possible mismatches between manpower supply and demand. Early identification of supply shortfalls could lead to weapon system designs that accommodate those shortfalls and minimize the need for costly and time consuming redesign later in a program. Finally, an earlier and more complete recruiting strategy will be possible and greater assurance of minimizing personnel shortfalls should result.

Other reports that document the work performed under the contract named above are listed in Appendix A.

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LIST OF EXHIBITS

I. INTRODUCTION

The Office of the Secretary of Defense (OSD) has recently placed emphasis on the earlier and more thorough estimation of weapon system resource requirements in the acquisition process. This emphasis resulted from a recognition that:

- manpower is becoming increasingly scarce and expensive,
- weapon systems are becoming more and more technologically complex, and
- efforts to shorten the acquisition cycle impose a need for earlier manpower planning.

The environment created by these conditions is one that imposes a requirement for early manpower planning, and close coordination between manpower planners and system designers, in order to effectively field, operate, and maintain weapon systems.

A. BACKGROUND

Management Consulting & Research, Inc. (MCR) has been tasked by the Office of the Assistant Secretary of Defense for Manpower, Installations and Logistics [OASD(MI&L)], to recommend a procedure for integrating long-range manpower demand projections across individual weapon systems and across Services. Although long-range projections of manpower requirements are made by the Services, those projections have not been stated in terms that readily permit their comparison to supply projections. In addition, the long-range supply projections that have been made have not been cast in a way that makes them readily, if at all, usable

by system designers. MCR's work has addressed both of these problems.

MCR's work on the demand side of the problem has focused on development and demonstration of a methodology for projecting weapon system-specific enlisted manpower requirements in the Concept Exploration Phase of a weapon system acquisition. The Early-On Manpower Requirements Estimation Methodology (EMREM) is the resulting methodology, and was successfully tested on data from the M1 Abrams Main Battle Tank program, and the AH-64 (Apache) and UH-60A (Black Hawk) helicopter programs. The results of that analysis showed the following:

- EMREM is an effective method for projecting the manpower requirements of systems that are in the Concept Exploration Phase. It's application during concept exploration will provide manpower estimates much earlier in the acquisition process than they are currently developed.

- EMREM is consistent with the comparability analysis outlined in MIL-STD-1388-1A, Logistic Support Analysis. The types of data required for EMREM are similar to those developed in the logistic support analysis (LSA) process. However, EMREM requires less detailed data on subsystems that are generally developed for LSA.

There are several desirable uses for manpower requirements estimates that are produced early in the acquisition process of a new system. The one most germane to this project is the ability to compare those estimates to the projected availability of personnel. That comparison would indicate whether changes in recruiting and training plans are needed in order to support the new system once it is fielded.

One task in MCR's analyses of manpower supply issues was to develop a mechanism for comparing manpower supply and demand

estimates. The Aptitude Cluster concept was developed in order to establish common terms in which supply and demand estimates could be posed. Aptitude Clusters represent, at an aggregate level, those characteristics and capabilities identified as necessary for the performance of particular military jobs. The cluster concept reflects the common relationships among the various Service aptitude composites. As such, the Aptitude Clusters, in contrast to aptitude composites, are not Service-specific.

The supply and demand methodologies, mentioned above, provide a combined capability to:

- estimate weapon system-specific demand for manpower during a system's Concept Exploration Phase,
- state that demand using the classification method provided by the Aptitude Cluster concept, and
- examine the projected supply of military manpower using that same classification method.

However, in order to compare supply and demand projections in a meaningful way, a method is needed whereby demand can be aggregated across weapon systems. That is the subject of this report.

B. ORGANIZATION OF THIS REPORT

The remainder of this report is divided into three major sections and three appendices. Section II contains a discussion of long-range manpower requirements determination. That section discusses the problems associated with such long-range estimates, as well as the shortfalls of the current long-range manpower requirements determination process. Section III contains a description of an approach for integrating long-range manpower re-

quirements estimates at the Service level and across Services. Section IV contains conclusions drawn from this analysis and a set of recommendations.

Appendix A lists references to prior MCR work on this project. Appendix B presents an overview of the Aptitude Cluster concept and Appendix C provides an overview of EMREM.

II. LONG-RANGE MANPOWER REQUIREMENTS DETERMINATION

Each of the Services makes long-range projections of manpower requirements for individual weapon systems. For individual systems, those projections are first made during the weapon system acquisition process. However, they are generally not made earlier than for Milestone II of the Defense System Acquisition Review Council (DSARC) process. Those estimates are then revised periodically, through the remainder of the system's acquisition and its deployment, as part of the Planning, Programming, and Budgeting System (PPBS). Total Service-level requirements are determined during the PPBS process using, as a base, weapon system-specific requirements projections and estimates of administrative, support, and ancillary personnel. Short- and mid-term requirements are specified as part of the annual Five Year Defense Plan (FYDP); long-range requirements are specified in the Extended Planning Annex of the FYDP.

This section provides an overview of factors that must be considered in developing long-range estimates of manpower requirements. In addition, a discussion of the shortfalls of the current estimation process is provided.

A. FACTORS TO CONSIDER

Exhibit II-1 displays a list of factors that must be considered in any procedure for estimating manpower requirements of the type considered here. This is not a definitive list by any means. It is only meant to illustrate some of the more important

- THE TIME PERIOD OF THE ESTIMATE
- THE FORCE STRUCTURE FOR THAT PERIOD
  - THE LIFE CYCLE STATUS OF EACH SYSTEM
  - THE USAGE RATE OF EACH SYSTEM
  - THE OPERATIONAL ENVIRONMENT/ SCENARIOS FOR THE SYSTEMS DEPLOYED
  - THE MAINTENANCE PHILOSOPHY FOR EACH SYSTEM/SYSTEM TYPE
  - THE MANNING PHILOSOPHY FOR EACH SYSTEM/SYSTEM TYPE
  - CROSS-UTILIZATION POTENTIAL FOR PERSONNEL
  - THE SEASONALITY OF DEMAND
  - MOBILIZATION UNIQUE WORKLOAD
- WORKWEEK FACTORS AND SHIFT SCHEDULES
- WORKLOAD THAT IS CONSTRAINED BY EQUIPMENT AVAILABILITY OR PHYSICAL CAPACITY
- NON-AVAILABLE TIME OF PERSONNEL
- PERSONNEL PRODUCTIVITY
- PLANNING FACTORS TO ACCOUNT FOR
  - PATIENTS, PRISONERS, STUDENTS AND TRANSIENTS
  - ROTATION OF PERSONNEL

Exhibit II-1. FACTORS TO CONSIDER IN ESTIMATING OPERATOR AND BELOW DEPOT-LEVEL MANPOWER REQUIREMENTS FOR WEAPON SYSTEMS

factors that must be taken into account when making estimates of the type discussed. Several of these factors are discussed below.

The time period of the estimate determines the force structure that will be used as the basis of the manpower requirements estimate. The force structure specification will indicate the number of units of each system for which manpower will be estimated. The time period and the force structure will determine the life cycle status for systems. The life cycle status of systems in the projected force (e.g., in the year 2000) will determine the kind of manpower estimate that is made for a given system. For instance, there will be many M1 tanks fielded in the year 2000. Some may have been in the field for 15 years, while others may just have been deployed. The older tanks may experience different repair rates than the newer tanks. Thus, use of a "fleet repair rate" may distort manpower requirements, especially if the tanks are not grouped into units uniformly by age.

In addition, systems in the field in the year 2000 may still be in acquisition when the manpower projection is made. Different manpower estimation techniques will apply based on where a system is in the acquisition cycle. If the system is in the Concept Exploration Phase, EMREM (Early-on Manpower Requirements Estimation Methodology) might be used. If the system is further along in the acquisition process, HARDMAN or LCOM (the Air Force Logistics Composite Modeling system) may be applicable. In order to apply any of these estimation techniques, assumptions will

have to be made concerning system usage rates, maintenance philosophies, and the operational environment of the system.

In building a manpower estimate that covers several different systems, an important factor to consider is the cross-utilization of personnel for those systems that are co-located. Not properly accounting for the cross-utilization of personnel could lead to overstating manpower requirements. The determination of cross-utilization should take into account the location of the system(s) involved (they must be co-located, or their repair centers should be), the maintenance philosophy employed, demand fluctuation (seasonality), the availability of spares on-site, and repair times.

Estimates of manpower requirements for a Service should include an indication of the sensitivity of the estimate to uncertainties in the data used. Those uncertainties include the schedule for the phase-in and phase-out of systems, the timing of unit replacements, the adequacy of the logistics pipeline, and many other elements that directly affect total manpower requirements.

When aggregating manpower requirements across Services, care must be taken to ensure that the estimates are consistent and expressed in the same units (e.g., maintenance manhours per year). Thus, requirements for aircraft maintenance expressed as maintenance manhours per flying hour might have to be converted using a flying hour program plan. Only when all of the various elements are expressed in the same terms can they be combined into a unit-or Service-level requirements estimate.

There are many elements that directly affect system workload requirements and they must also be accounted for in estimating manpower levels. These elements include:

- the mix between various levels of maintenance;
- make ready/put away time; and
- unauthorized absences, leave, and temporary duty, including training.

For each of these elements, there are several factors that affect workload. Factors such as reliability and maintainability affect the amount of maintenance work to be done. The tempo of operations and numbers of each deployed system affect the number of system operators required. The availability of repair facilities can determine the time frame in which repairs can be performed and the elapsed time needed for completing repair work. Moreover, workload, especially repair work, varies with the environment in which systems operate. Weather, tempo of operations, and location of operations, can affect the performance of systems and, therefore, maintenance workload.

In addition, personnel availability (i.e., the percent of a total workweek that can be productively spent on the job), also affects the workload. In turn, personnel availability is determined by such elements as leave, the need for medical care, disciplinary action, and many other factors.

Maintenance strategies, such as work deferral and redistribution of tasking to under-tasked work centers, help to relieve

workload pressures and assist in improving personnel productivity.

One of the biggest problems in attempting to integrate manpower estimates across weapon systems stems from the fact that a force programmed for the year 2000, for instance, will have systems that are at different stages of development or age when the estimate is made. There are different manpower requirements estimates that are generated for systems at various stages of the development cycle and system life cycle. The level of uncertainty of the estimates varies from estimate to estimate and is largely unquantifiable, especially for estimates made during system development.

The impact of all of the above elements must be considered in the estimation of system manning requirements. Clearly, however, they cannot all be considered from the very outset of system acquisition. However, they must be considered, and are to varying degrees of detail, at different stages of the acquisition process.

B. SHORTFALLS OF THE CURRENT PROCESS

Until recently the major problem with long range manpower planning has been that no sound methodology existed for projecting manpower requirements for systems in Concept Exploration. That deficiency usually resulted in a late evaluation (at DSARC Milestone II) of system manpower requirements. The net result of that shortcoming of the design review process has been that manpower considerations have not had sufficient impact on system

design. Thus, in preparation for IOC, the training base for systems has sometimes been stressed to the limit. The ripple effect of insufficient manning or complex equipment which is beyond the technical abilities of available manpower has obvious ill-effects. The need for contractor maintenance, additional system down-time, or poor system operation all impose contraints on U.S. warfighting capability.

Each of the Services has addressed this issue. The result has been that techniques have been devised that permit the early assessment of system manpower requirements. The Army is developing MIST (Man-Integrated System Technology) and the Air Force uses elements of LCOM (Logistic Composite Model). The Navy and Marine Corps are currently testing the HARDMAN Methodology. The Navy has also developed and successfully used MDM (Manpower Determination Methodology) and ASSET (Advanced Surface Ship Evaluation Tool). Both MIST and HARDMAN have yet to be fully integrated into the manpower planning process and, although MDM and ASSET are in current use, both have shortfalls as discussed below.

1. The Manpower Determination Model

The Manpower Determination Model (MDM) was designed by the Naval Sea Systems Command (NAVSEA). The group within NAVSEA responsible for the maintenance and use of the model is the Manning and Controls Integration Branch (SEA 55W52) in the Naval Architecture Sub-Group of the Ship Design and Engineering Directorate. MDM was developed for use during the initial stages of

the design process. It is then, when little is known about the actual design of a new ship, that MDM plays a major role. The model is used to make preliminary estimates of ship manning, and is used to help ship designers account for constraints imposed by manning restrictions.

The MDM methodology uses comparability analysis to perform manning estimation. The MDM data base contains modules that represent weapon system and ship function manning requirements, workload factors, and cross-utilization factors. Each module contains such information for a single ship system and reflects the Navy's aggregate operations and maintenance experience with that system. The modules are the "building blocks" in the design of a notional ship, one that closely represents the new ship to be designed and constructed. The manning estimate for the notional ship is calculated using the combined workload and cross-utilization factors for each module selected.

MDM calculates the total requirement for officers, warrant officers, chief petty officers, and other enlisted personnel. The cross-utilization factors are used to ensure that each individual is as fully utilized as possible. The estimate produced by MDM projects the number of personnel required in each rating and pay grade combination to operate and maintain the notional ship.

Data base modules have been constructed for many individual ship systems. However, much work remains to be done to keep the MDM data base current and to upgrade it to cover many

more systems. It is currently concentrated on surface ships and does not provide data for naval aircraft or for submarines. The methodology, however, is general enough to include those platforms. MDM's inclusion in the HARDMAN Methodology may provide added impetus for expanding its capability and role.

2. The Advanced Surface Ship Evaluation Tool

The Advanced Surface Ship Evaluation Tool (ASSET) is designed for use during the course of exploratory studies, feasibility design studies, and, to a limited extent, preliminary ship design. The ASSET model was designed and is currently maintained and exercised by the Advanced Concepts Office of the David Taylor Naval Ship Research and Development Center (DTNSRDC).

The principal benefits of ASSET include its ability to provide an integrated perspective of all major ship functions and an early, rapid assessment of ship designs. The current version of ASSET contains modules to perform calculations of hull geometry and structure, resistance, propeller design, machinery placement and use, and total ship weight. These design factors are analyzed for ship performance, hydrostatics, seakeeping, cost, space, and manning.

ASSET's manning module is designed to provide manning requirements estimates at the ship department level of detail. The current algorithms of the ASSET manning module perform parametric estimation of manning requirements using full load weight as the determining variable.

Once a manning estimate is determined, the ASSET model uses it to assess its impact on space availability, full load displacement, and ship cost and performance. A convergence algorithm is then entered to determine whether design and manning constraints are met. If not, the model iterates and determines new estimates. This procedure is repeated until design and manning constraints are met and until preset tolerances are satisfied.

There are a number of ways in which the ASSET manning module can be enhanced. As mentioned, the model currently bases its manpower estimation on algorithms that use full load weight as the only parameter. The model can incorporate other parameters (e.g., workload, personnel availability, and readiness condition), and can be further enhanced by the development of non-parametric algorithms. These modifications have, in fact, been suggested by the Advanced Concepts Office of DTNSRDC. The ASSET model is currently used in ship design analysis to explore trade-offs among various factors that affect ship performance and cost.

Although each of the systems named above provides a significant capability in manpower estimation, there are still many improvements that can be made. Some of these improvements are discussed in the next section.

III. A STRATEGY FOR INTEGRATED MANPOWER ESTIMATION

In order to comply with guidance provided by MIL-STD-1388-1A, Logistic Support Analysis, manpower planners will have to develop estimates of weapon system manpower requirements during Concept Exploration. Although refined manpower estimates are made later in the system acquisition process, perhaps the most critical manpower estimates are those that can be made during Concept Exploration. It is then that initial decisions are made which will determine critical system characteristics such as system size, performance characteristics, acquisition costs, and operations and maintenance costs.

As mentioned in Section II, the Services are addressing the question of early manpower estimation. OSD has also addressed this problem. Elements of MIL-STD-1388-1A are the result of OSD's recognition of a need for early-on manpower requirements determination. Development of the Early-on Manpower Requirements Determination Methodology (EMREM), which is discussed in Appendix C, was sponsored by OSD in response to that need.

Thus, progress has been and continues to be made in determining early-on manpower requirements for individual systems. The next step is to develop a methodology for integrating the early determinations of manpower requirements for individual

systems with manpower estimates for other systems. This section discusses how that might be accomplished for operator personnel and below depot-level support personnel.

A. SERVICE-LEVEL ESTIMATES

One of the problems in attempting to integrate manpower estimates across weapon systems stems from the fact that a force programmed for the year 2000, for instance, will have systems that are at different stages of development or age when the estimate is made. There are different manpower requirements estimates that are generated for systems at various stages of the development cycle and life cycle. The level of uncertainty of the estimates varies from estimate to estimate and is largely unquantified, especially for estimates made during system development.

Furthermore, the state of manpower estimation at various stages of the development process is more advanced for some stages. For instance, during Concept Exploration for a system, it is often the case that the military occupational specialty to perform a particular task hasn't been completely identified. For apprentice personnel, requirements can be stated in categories of capability known as Aptitude Clusters (see Appendix B). A difficulty arises, however, with journeyman/supervisor personnel. At this point, no such clustering concept has been developed. However, as we shall see, it is still possible to make preliminary estimates of manpower requirements, both at the system level and across systems.

The discussion that follows assumes that the reader is familiar with both the Aptitude Cluster concept for enlisted apprentices and EMREM. These two subjects are discussed in Appendices B and C, respectively.

As mentioned above, long-range manpower estimation requires consideration of systems that are at various stages of the system life cycle. For systems that are in the Demonstration and Validation Phase of the DSARC cycle (i.e., are close to DSARC Milestone II) manpower estimation processes are fairly well defined. This also applies to systems that are past Milestone II. That is not to say that perfectly accurate estimates of manpower requirements are made then, but that the need for estimates then is well-recognized and that estimates are developed. The estimates made for DSARC Milestone II and later in the system life cycle project system manpower requirements by Service-specific military occupation and pay grade. These estimates form a base upon which the proposed method is built.

To begin, consider a system that is either approaching DSARC Milestone II (i.e., is near the end of the Demonstration and Validation Phase) or is later in its life cycle. Life cycle enlisted manpower estimates for that system will have been made and, for any given year, might be displayed as in Exhibits III-1 and III-2. Exhibit III-2 presents an Army example. This table would present total enlisted manpower requirements for all fielded units of a particular system, or all units of that system expected to be fielded in a given fiscal year. With such a table

MILITARY OCCUPATION	NUMBER OF PERSONNEL
XX	XX
XX	XX
XX	XX
XX	XX
XX	XX

(x) ARMY MOS, NAVY RATING, MARINE CORPS MOS, AIR FORCE SPECIALTY CODE.

Exhibit III-1. TABLE SHELL FOR TOTAL OPERATOR AND BELOW DEPOT-LEVEL ENLISTED MANPOWER REQUIREMENTS FOR SYSTEM X IN FYxx

MILITARY OCCUPATIONAL SPECIALTY	NUMBER OF PERSONNEL		
	ORG[1]	DS[2]	GS[3]
XX	X	X	X
XX	X	X	X
XX	X	X	X
XX	X	X	X
XX	X	X	X

1, ORGANIZATIONAL LEVEL PERSONNEL
2. DIRECT SUPPORT PERSONNEL
3. GENERAL SUPPORT PERSONNEL

Exhibit III-2. TABLE SHELL FOR ARMY TOTAL ENLISTED OPERATOR AND BELOW DEPOT-LEVEL MANPOWER REQUIREMENTS FOR A SYSTEM IN A GIVEN FISCAL YEAR

developed for each system near or after DSARC Milestone II, a Service-wide estimate of enlisted manpower requirements for those systems could be developed. That estimate would take into account cross-utilization of personnel for systems that are co-located, and other planning factors that account for items such as those listed in Exhibit II-1.

The result of this procedure would be an estimate, by fiscal year, of total enlisted manpower requirements for operator personnel and below depot-level support personnel. That estimate would cover a given force structure of fielded systems, but only for those systems at or after DSARC Milestone II when the estimate is made.

In order to accommodate the remaining portion of the force structure (i.e., those systems in Concept Exploration or early in Demonstration and Validation) another procedures must be considered. The reason for introducing another procedure is that, as discussed above and in Appendices B and C, the lack of specificity in system descriptions early in acquisition prevents very detailed manpower estimation.

The Aptitude Cluster concept was developed to enable consideration of manpower requirements when little is known about the requirement, even the exact military occupation. The cluster concept, as currently designed, groups skills and capabilities into seven areas:

- General,
- Administrative/Clerical,
- Technical,

- Mechanical,
- Mechanical Maintenance,
- Combat, and
- Field.

Exhibit B-5 displays the relationship of Service aptitude composites to the cluster concept.

By employing Aptitude Clusters as the categories into which Milestone I manpower requirements and estimates could be stated, one could develop a Service-wide estimate of below depot-level personnel requirements in one of two ways. The first is depicted in Exhibit III-3. It shows requirements specified in two distinct categories. The first is for apprentices and the second is apprentices and journeymen/supervisors. The first category covers the apprentice skills required for systems that are in Concept Exploration or early in Demonstration and Validation when the estimate is made. The second category includes the requirements for:

- journeymen/supervisors for systems that are in Concept Exploration or early in Demonstration and Validation when the estimate is made, and
- both apprentices and journeymen/supervisors for systems that are close to or past Milestone II of the DSARC process.

Clearly, alternative table forms are possible in this case, and one could, for instance, easily build in a display of information by pay grade or years-of-service.

	APTITUDE CLUSTER	MILITARY OCCUPATIONAL SPECIALTY	NUMBER OF PERSONNEL		
			ORG	DS	GS
APPRENTICES	GENERAL	TWO DIGIT MOS	X	X	X
	ADMINISTRATIVE/ CLERICAL		X	X	X
	TECHNICAL		X	X	X
	MECHANICAL		X	X	X
	MECHANICAL MAINTENANCE		X	X	X
	COMBAT		X	X	X
	FIELD		X	X	X
		SUBTOTAL	X	X	X
APPRENTICES JOURNEYMEN/ SUPERVISORS		TWO DIGIT MOS	X	X	X
			X	X	X
			X	X	X
			X	X	X
			X	X	X
			X	X	X
		SUBTOTAL	X	X	X
		TOTAL	X	X	X

Exhibit III-3. TABLE SHELL FOR A MULTI-MODE ESTIMATE OF SERVICE-WIDE MANPOWER REQUIREMENTS - ARMY EXAMPLE

A second way to depict the requirements estimate is shown in Exhibit III-4. This table, which could also include break-outs by pay grade or years-of-service, provides a higher-order aggragation of information then does the table displayed in Exhibit III-3. As such, some information is lost. However, it is not difficult to envision uses for the information in both examples, and both could prove very useful for developing Service-wide estimates of manpower requirements.

B. DoD-WIDE ESTIMATES

Once Service-wide estimates have been developed, the next step would be to develop DoD-wide estimates of below depot-level manpower requirements. Because of the disparity of occupational codes and titles, one could use the Aptitude Cluster categories as a table stub as in Exhibit III-4. The columns could then be labeled as in Exhibit III-5, with the appropriate headings filled in for each Service. Again, as above, additional break-outs by pay grade and years-of-service are possible.

Now, Exhibit III-5 does nothing more than place Service-specific examples of Exhibit III-4 side-by-side. In order to develop an aggregation across DoD, a mapping would have to be developed that would uniquely allocate the various below-depot level maintenance personnel to categories. For purposes of long range planning, one possibility is to simply combine all maintenance into a single grouping and display the estimate as in Exhibit III-6. Again, pay grade and years-of-service break-outs would add information to the table.

APTITUDE CLUSTER	NUMBER OF PERSONNEL		
	ORG	DS	GS
GENERAL	X	X	X
ADMINISTRATIVE/ CLERICAL	X	X	X
TECHNICAL	X	X	X
MECHANICAL	X	X	X
MECHANICAL MAINTENANCE	X	X	X
COMBAT	X	X	X
FIELD	X	X	X
TOTAL	X	X	X

Exhibit III-4. TABLE SHELL FOR SINGLE MODE ESTIMATE OF SERVICE-WIDE MANPOWER REQUIREMENTS - ARMY EXAMPLE

APTITUDE CLUSTER	NUMBER OF PERSONNEL						
	ARMY			NAVY		AIR FORCE	MARINE CORPS
	ORG	DS	GS	ORG	INTERMEDIATE	---	---
GENERAL	X	X	X	X	X	X	X
ADMINISTRATIVE/ CLERICAL	X	X	X	X	X	X	X
TECHNICAL	X	X	X	X	X	X	X
MECHANICAL	X	X	X	X	X	X	X
MECHANICAL MAINTENANCE	X	X	X	X	X	X	X
COMBAT	X	X	X	X	X	X	X
FIELD	X	X	X	X	X	X	X
TOTAL	X	X	X	X	X	X	X

Exhibit III-5. TABLE SHELL FOR DOD-WIDE MANPOWER REQUIREMENTS ESTIMATE BY SERVICE

APTITUDE CLUSTER	NUMBER OF PERSONNEL	
	OPERATORS	MAINTENANCE
GENERAL	X	X
ADMINISTRATIVE/ CLERICAL	X	X
TECHNICAL	X	X
MECHANICAL	X	X
MECHANICAL/ MAINTENANCE	X	X
COMBAT	X	X
FIELD	X	X
TOTAL	X	X

Exhibit III-6. TABLE SHELL FOR DOD-WIDE MANPOWER REQUIREMENTS ESTIMATE

IV. CONCLUSIONS AND RECOMMENDATIONS

In prior reports on this study effort (see Appendix A), the following conclusions were reached:

- the Aptitude Cluster concept permits consideration of the supply and demand for enlisted apprentice manpower at a time in the acquisition process when manpower requirements are generally not developed;
- EMREM is consistent with the comparability analysis outlined in MIL-STD-1388-1A, Logistic Support Analysis; and
- useful manpower estimates for individual systems can be developed during Concept Exploration.

The analyses that led to these conclusions resulted in the following recommendations:

- the Aptitude Cluster concept should be adopted by OSD and the Services, and should be used in early-on system manpower estimation; and
- analyses like those permitted by EMREM should be performed during the Concept Exploration phase of system acquisition.

As a result of current investigations, we conclude that sufficient information is available to enable integration of EMREM analyses with other manpower estimates to obtain both Service-wide and DoD-wide manpower estimates for systems. Thus we recommend that:

- the Services institute definite procedures for developing EMREM-like estimates during Concept Exploration for individual weapon systems;
- the Services integrate those estimates to provide Service-wide long-range estimates of manpower requirements that can be compared to manpower supply estimates in a meaningful fashion; and

- OSD or a joint Service task force integrate Service-wide estimates in order to enhance comparison of projections of manpower supply with total weapon system manpower requirements, especially for enlisted apprentices.

APPENDIX A

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APPENDIX B

OVERVIEW OF APTITUDE CLUSTER DEFINITIONS

The Military Services have a basic need to evaluate the acceptability of persons entering the Service, regardless of whether entrance is voluntary or not. It is necessary to determine whether individuals are medically and morally "fit," as well as capable of being trained and having sufficient orientation to perform any of the required jobs the Service has identified. The acceptability of an applicant is determined through a variety of measurements, some of which are common to all of the Services and some of which are Service-unique.

In this appendix, we present a brief review of military aptitude testing, a description of the Services' aptitude classification schemes, and a description of the Aptitude Cluster concept.

A. REVIEW OF MILITARY APTITUDE TESTING

Modern military applicant acceptance testing dates from World War II. Evaluation of trainability and job performance capability has evolved over this period of time; however, the basic need to ascertain whether an applicant can succeed in being trained and can potentially perform any of the required jobs has not changed. Exhibit B-1 summarizes the development of modern aptitude testing.

Trainability is generally determined through a combination of attained education and the results of a standardized test. The Armed Forces Qualification Test (AFQT) has been used since 1950 as the basis for classifying the trainability of applicants.

Date	Evaluation of Applicant: Trainability	Evaluation of Applicant: Job Classification	Test
1940-1942	• Fourth Grade Education • Basic Literacy test	• Army General Classification Test (AGCT) - After Service Entry.	• Vocabulary, Arithmetic Reasoning, Spatial Ability; Mechanical and clerical tests subsequently added.
1943-1945	• Minimal Literacy Requirement dropped	• AGCT - Also used by Army for enlistment screening	
1950	• Armed Forces Qualification Test (AFQT) - modeled after the AGCT		
1973-1975	• Common AFQT replaced by Service-specific test batteries		
1976	• Reinstatement of common AFQT; calculated from selected ASVAB subtests	• Introduction of Armed Services Vocational Aptitude Battery (ASVAB) forms 6 and 7	See Exhibit B-2 for specific subtests.
1980		• ASVAB forms 8, 9 and 10; replaced forms 6 and 7	

Sources: "Profile of American Youth: 1980 Nationwide Administration of the Armed Services Vocational Aptitude Battery," OASD (MRA&L), March 1982.

"Aptitude Testing of Recruits: A Report to the House Committee on Armed Serivces," OASD (MRA&L), July 1980.

Exhibit B-1. SUMMARY OF HISTORY OF MILITARY APPLICANT TESTING

A variety of calculation schemes have been used during this time, with the AFQT currently being calculated based on selected scores in the standard aptitude test used to analyze applicant job performance capability.

Applicants are classified by the AFQT into one of five mental categories, with Category I being the highest (representing those in the 93rd percentile and above), and Category V, the lowest (representing those in the 9th percentile and below). The Services do not accept applicants in Category V, and accept only a limited number in Category IV, generally in Category IVA (those between the 21st and 30th percentiles).

Job performance capability has, since World War II, been evaluated through testing for selected aptitudes. Since 1976, the aptitude testing of applicants has been based on the Armed Services Vocational Aptitude Battery (ASVAB). Instituted in 1976 as a cross-Service standard test, it replaced the Service-specific tests in use at that time. The ASVAB was designed to eliminate the previously used two-step testing process by combining the AFQT and job classification in a single test.

The ASVAB is composed of a number of specialized subtests designed to measure existing abilities and knowledge in distinct areas. Three versions of the ASVAB have been used: forms 6 and 7, used from January 1976 to October 1980; forms 8, 9 and 10, instituted in October 1980 and is use until October 1984; and the current version of the ASVAB, forms 11, 12 and 13. The ASVAB is revised approximately every three years to update the terminology

and content of questions. As can be seen in Exhibit B-2, there has also been some change in the selection of subtests composing the battery. The set of ten subtests in forms 8, 9, 10 is, however, expected to remain the same in the foreseeable future.

As noted before, the ASVAB is used to assign applicants to a mental category as well as evaluate their potential job suitability. Four of the ASVAB subtests are used as the AFQT:

- Arithmetic Reasoning,
- Numerical Operations,
- Paragraph Comprehension, and
- Word Knowledge.

These same tests, as well as the six other subtests are also used by each of the Services to analyze applicant aptitudes for job classification. Specific sets of subtests are determined by each Service as representative of the types of knowledge or ability needed for particular jobs in the Service. The Services construct aptitude composites based on combinations of these subtests, with minimum combined score requirements used as a measure of a specific aptitude or job capability. This approach is used by all of the Services for initial job classification, with more specialized tests for proficiency used for occupations requiring higher skill levels, such as for language experts. The Services' aptitude composite schemes are discussed in detail below.

B. DESCRIPTION OF SERVICE COMPOSITES

An important requirement for all of the Services is the

Forms 6 and 7 (1976-1980)	Forms 8, 9 and 10 (1980-1984)
General Science	General Science (GS)
Arithmetic Reasoning	Arithmetic Reasoning (AR)
Work Knowledge	Word Knowledge (WK)
	Paragraph Comprehension (PC)
Numerical Operations	Numerical Operations (NO)
	Coding Speed (CS)
Automotive Information	Automotive Shop (AS)
Shop Information	
Mathematics Knowledge	Mathematics Knowledge (MK)
Mechanical Comprehension	Mechanical Comprehension (MC)
Electronics Information	Electronics Information (EI)
Attention to Detail	
Spatial Perception	
General Information	
Combat Scale	
Attentiveness Scale	
Electronics Scale	
Maintenance Scale	

Exhibit B-2. ASVAB SUBTESTS

matching of entrants to occupations. The mechanism for performing the initial matching is the ASVAB.

As previously discussed, the ASVAB subtests are used by the Services in various combinations to represent the types of capabilities required for particular jobs. These composites are designed based on Service-specific analysis of tasks and functions related to each entry-level enlisted military occupation.[1/] Emphasis is placed on apprentice-level occupations for several reasons:

- non-prior service applicants will usually only be eligible for apprentice-level positions;
- journeyman or more advanced occupations may require different aptitudes; and
- the aptitude relationships are generally only indirectly related to job characteristics.

The analysis of the relationship of job tasks and functions to the aptitudes or abilities an individual needs to perform them has not been able to be applied by all of the Services. Therefore, the Services analyze the aptitudes required to successfully complete the training necessary for the entry-level occupation instead. Thus, the relationship is not one of aptitude-to-job, but rather aptitude-to-training-to-job.

Aptitude composites are constructed, and minimum combined scores are set, based on the historic success rates of applicants

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1/ This discussion of Service aptitude composites and the subsequent discussion of Aptitude Clusters relates only to enlisted personnel, since that group is the focus of the research on this project.

and the probability that individuals with various scores will successfully complete their training, given the content and duration of the courses. Incorporated in this analysis is the overall requirement for trained personnel in the related occupations. The impact of attained education is considered in the determination of minimum scores on the particular combinations of aptitude tests, with non-high school graduates usually required to achieve higher scores than holders of high school diplomas. This is because there tends to be a higher rate of training failures for non-high school graduates than for high school graduates.

The Services are continually reviewing and updating their aptitude composites in order to maintain a close relationship between aptitude requirements and the related occupation. This relationship is generally reviewed annually, with the score requirements usually reviewed more frequently.

Exhibit B-3 lists the aptitude composites currently used by each of the Services.[2/] Three of the aptitude composites are common among all of the Services: General (sometimes referred to as General Technical), Administrative (sometimes referred to as Clerical), and Electronics. Each Service uses the same sets of subtests for each of these composites; only the minimum score requirements are different.

2/ The Navy aptitude composites are identified, in some cases, by terms developed by MCR for this study due to the need for structural similarity among the composites.

Army	Navy
General Technical	General
Clerical	Administrative
Electronics	Electronics
General Maintenance	Skilled Technical*
Skilled Technical	Nuclear*
Field Artillery	Mechanical Technical*
Combat	
Operators/Food	
Surveillance Communications	
Mechanical Maintenance	

Marine Corps	Air Force
General Technical	General
Clerical	Administrative
Electronics	Electronics
General Mechanical	Mechanical
Field Artillery	
Combat	
Mechanical Maintenance	

* MCR designations

Exhibit B-3. SERVICE APTITUDE COMPOSITES

Exhibit B-4 lists the ASVAB subtests used in each of the Service aptitude composites (see Exhibit B-2 for the names of the subtests). In addition to the three common composites, the Services also have varing numbers of other composites, with the Air Force having the fewest (four) and the Army the most (ten). Examination of Exhibit B-4 shows that more than one Service may have an aptitude composite similar in structure (i.e., composed of the same combination of subtests) to another Service composite. Examples of this are the Army's General Maintenance composite and the Marine Corps' General Mechanical Composite, both of which are composed of the Math Knowledge (MK), General Science (GS), Electronics Information (EI), and Automotive Shop (AS) subtests. Conversely, the same name may be used by two Services and yet the composites are not constructed using the same combination of subtests. Examples of this are the Army and Marine Corps Field Artillery and Combat composites. Both composites are used by each of these two Services but do not, in actuality, represent the same set of aptitude requirements. These types of differences (composite name vs. content) had significant influence on this analysis and construction of the Aptitude Clusters.

Exhibit B-4 also illustrates that the Services do not, apparently, have heavy dependence on any particular subtest, but rather have fairly scattered requirements, with the Numerical Operations and Coding Speed subtests used the least and Automotive Shop used the most. It should be mentioned that the assignment of subtests to composites has been made based on Service-

SERVICE	APTITUDE COMPOSITE	ASVAB SUBTESTS									
		AR	MK	NO	CS	PC	WK	GS	EI	MC	AS
Army, Navy, Marine Corps, Air Force	General/General Technical	X				X	X				
	Administrative/Clerical			X	X	X	X				
	Electronics	X	X					X	X		
Army	General Maintenance		X					X	X		X
	Skilled Technical		X			X	X	X		X	
	Field Artillery	X	X		X					X	
	Combat	X			X					X	X
	Operators/Food			X		X	X			X	X
	Surveillance Communic.			X	X	X	X				X
	Mechanical Maintenance	X							X	X	X
Navy	Skilled Technical	X				X	X			X	
	Nuclear	X	X			X	X	X	X		X
	Mechanical Technical					X	X			X	X
Marine Corps	General Mechanical		X					X	X		X
	Field Artillery	X				X	X			X	
	Combat			X		X	X				X
	Mechanical Maintenance	X							X	X	X
Air Force	Mechanical							X		X	X

Exhibit B-4. SERVICE APTITUDE COMPOSITE SUBTEST COMPOSITION

provided data. In the case of the Army, Air Force, and Marine Corps, information is available on the combination of subtests and the combined minimum scores required in an aptitude composite in order to qualify for particular schools. The Navy, with a somewhat more complicated system, more directly relates subtests and minimum scores to particular training options, and places less emphasis on specific aptitude composites. For this reason, we have identified and named aptitude composites in the Navy which tend to relate to the training options more than the Navy's formal aptitude composites. Thus, we have identified the Nuclear composite, which relates to the qualifications necessary for nuclear ratings. This training would be in addition to the actual occupation-specific (i.e., rating) training an apprentice would receive. However, given the fact that the Navy has requirements for nuclear qualified ratings, we believed this should be reflected. Further adjustments in the identification of the Navy aptitude composites were made in constructing the Aptitude Clusters; these are discussed below.

It should also be noted that, in some cases, a Service may have an aptitude composite which is <u>not</u> currently related to occupations within the Service. There are two such cases of "inactive" aptitude composites: the Army's General Technical and the Marine Corps' General Mechanical. In the case of the Army's General Technical, however, applicants must achieve a specified minimum score in order to be accepted by the Army. While this composite is not used in classifying applicants for particular

Army schools, it is used in the overall qualification analysis. The Marine Corps' General Mechanical has only recently been made inactive, with all of the occupations originally assigned to this composite distributed among the remaining composites.

C. DESCRIPTION OF APTITUDE CLUSTERS

In order to relate a projection of manpower supply to a projection of manpower demand, a mechanism for translating these estimates into common terms is necessary. This mechanism is the Aptitude Cluster. The Aptitude Cluster is intended, at an aggregate level, to represent those characteristics and capabilities identified by each of the Services as "necessary" for the performance of particular military jobs. It reflects the common relationships (i.e., similarity of aptitude requirements based on combinations of subtests) of aptitude composites among the Services. As such, the Aptitude Cluster, as opposed to the aptitude composite, is non-Service specific. The cluster represents the common characteristics shared by several composites, and is designed to represent an aggregation of several aptitude composites.

Given the ability to relate Services' aptitude composites to each other and to represent them at a more aggregate level, it is possible to translate weapon system-specific manpower requirements to the related Aptitude Cluster. In this translation, the distinctions which are made at the Service level among occupations are blurred, so that those occupations which use the same "types" of people are collectively represented as a single "type"

of requirement. Conceivably, within the Services, as well as among the Services, competition occurs for "types" of people to support specific occupational requirements.

The Aptitude Clusters can also be applied to manpower supply projections as a mechanism for tailoring, or characterizing, the projected population. This is necessary in order to add another dimension to the population, the distribution of those capabilities which the population may have and which the Services need in their apprentices. In this use, the Aptitude Clusters are used in conjunction with historic ASVAB scoring data to show the overall distribution of aptitudes in the projected population.

Given the aggregate nature of the Aptitude Clusters, it was necessary to identify the characteristics common among the Services' composites. As can be seen from the preceeding discussion, the Services' aptitude composites vary widely in numbers and composition.

Exhibit B-4 shows that the distribution and variety of subtest combinations at the subtest level of detail was not a functional level at which to identify common characteristics. Initial consideration of the content of the subtests indicated that it was possible to group the subtests. This grouping is based on the similarity of the knowledge groups the subtests are addressing. There are two studies which have statistically analyzed these relationships.[3/]

3/ Dr. Darrell Bock of the University of Chicago has studied these relationships using the 1980 Profile of American Youth data. The Army Research Institute analysis is documented in Factor Structure of the Armed Services' Vocational Aptitude Battery (ASVAB), Forms 8, 9 and 10: 1981 Army Applicant Sample.

The relationships developed from the Profile of American Youth data were selected since they are based on the same data base used in developing MCR's manpower supply projections, and each subtest is assigned to a single subtest group, rather than more than one group. Four groups of subtests were used:

- Math, composed of Arithmetic Reasoning (AR) and Math Knowledge (MK);
- Speed, composed of Numerical Operations (NO) and Coding Speed (CS);
- Verbal, composed of Paragraph Comprehension (PC), Word Knowledge (WK), and General Science (GS); and
- Technical, composed of Electronic Information (EI), Mechanical Comprehension (MC), and Automotive Shop (AS).

The Services' aptitude composite/subtest combinations were arrayed according to these subtest groupings and are shown in Exhibit B-5.

The approach MCR has adopted in grouping the Service aptitude composites, according to the way in which the composite subtests align in the four groups, has been used for several reasons. First, the major intention of this analysis has been to demonstrate that such a structure is possible and that it provides additional insight into the aptitude characteristics of populations. It is not intended to be rigorously statistically validated, but rather to be the starting point for additional investigations, which may be more statistically oriented.

APTITUDE CLUSTER	SERVICE	APTITUDE COMPOSITE	ASVAB SUBTESTS									
			MATH		SPEED		VERBAL			TECHNICAL		
			AR	MK	NO	CS	PC	WK	GS	EI	MC	AS
General	Army	General Technical	X				X	X				
	Navy	General (Basic)	X				X	X				
	Navy	General (Electronics)	X	X					X			
	Marine Corps	General Technical	X				X	X				
	Air Force	General	X				X	X				
Administrative/ Clerical	Army	Clerical			X	X	X	X				
	Navy	Administrative			X	X	X	X				
	Marine Corps	Clerical			X	X	X	X				
	Air Force	Administrative			X	X	X	X				
Technical	Army	Electronics	X	X					X	X		
	Navy	Electronics	X	X					X	X		
	Marine Corps	Electronics	X	X					X	X		
	Air Force	Electronics	X	X					X	X		
	Army	General Maintenance		X					X	X		X
	Marine Corps	General Mechanical		X					X	X		X
	Army	Skilled Technical		X			X	X	X		X	
	Navy	Skilled Technical	X				X	X			X	
	Marine Corps	Field Artillery	X				X	X			X	
	Navy	Nuclear	X	X			X	X	X	X		X
Mechanical	Navy	Mechanical Technical					X	X			X	X
	Air Force	Mechanical							X		X	X
Mechanical Maintenance	Army	Mechanical Maintenance	X							X	X	X
	Marine Corps	Mechanical Maintenance	X							X	X	X
Combat	Army	Field Artillery	X	X		X					X	
	Army	Combat	X			X					X	X
Field	Army	Operators/Food			X		X	X			X	X
	Army	Surveillance/Communic.			X	X	X	X				X
	Marine Corps	Combat			X		X	X				X

Exhibit B-5. RELATIONSHIP OF APTITUDE COMPOSITES TO APTITUDE CLUSTERS

Second, this approach is designed to be consistent with how the Services currently use aptitude composites. It extends the current Service approaches to illustrate that composites may have relationships among themselves, both inter- and intra-Service. Since the purpose of this analysis does not include examination of the specific relationships among the occupations, training and associated composite, no attempt has been made to extend these definitions into these areas. However, clearly this is a potential course of investigation.

Finally, extensive statistical analyses have been performed of the content relationships of the ASVAB forms 8, 9, and 10, the ASVAB version which forms the basis for the current aptitude clusters. These are considered a sufficient statistical base for development of definitions of the current clusters.

As noted earlier, all four Services have three composites which are structurally composed of the same set of subtests and are, therefore, common to all. These are the General, Administrative/Clerical, and Electronics composites. Using the subtest grouping approach, it can be seen, however, that there are additional cases of common characteristics among several composites. These relationships among composites have been based on the combination of subtests in the four groups. This means that although one composite may use one subtest in a group, and another composite may not use the first subtest but does use another subtest in the same group, the two composites are considered related. Based on this analysis of subtest selections by

group, all of the composites have been related to each other and assigned to one of seven Aptitude Clusters.

As discussed earlier, some analytical judgement has been used in defining and assigning the Navy composites. Analysis at the subtest level assigned a number of very skilled electronics occupations to the Navy Skilled Technical and Electronics composites, although structurally they were not quite compatible. Analysis according to subtest groups allowed for the splitting out of these occupations into a separate composite, called here General (Electronics).

In addition to combinations of subtests, aptitude composites are also defined by the minimum combined scores required to qualify for occupations (i.e., training) in the composites. Within the composite, individual occupations are assigned minimum required scores. In order to determine the proportion of the population qualifying in each aptitude composite, it was necessary to select criteria for this qualification. A minimum combined score was identified for each aptitude composite based on analysis of the occupation qualification scores used by each Service. In those cases where large differences exist in the minimum combined score requirements for groups of occupations in a composite, the composite was restructured for MCR's analysis to reflect this. Thus, the Navy/General (Basic) and Navy/General (Electronics) composites belong to the same cluster, based on the analysis of their subtest requirements. However, they are

different composites, not only due to differences in subtest combinations, but also due to the large differences in the score requirements. A single minimum combined score was determined, based on analysis of the overall bottom end of the score range, for each Service composite in each cluster. These are shown in Exhibit B-6.

Aptitude Cluster	Service	Aptitude Composite	Related ASVAB Subtests	Minimum Score*	Application Rules
General	Army	General Technical	AR PC WK	N/A	• Not Applicable to Classif.
	Navy	General (Basic)	AR PC WK	90	• 90 for Basic Ratings
	Navy	General (Elect.)	AR MK GS	200	• 200 for Gen. Elect. Ratings
	Marine Corps	General Technical	AR PC WK	92	• Combined Scores
	Air Force	General	AR PC WK	87	• Combined Scores
Administrative/ Clerical	Army	Clerical	NO CS PC WK	138	• Combined Scores
	Navy	Administrative	NO CS PC WK	149	• Combined Scores
	Marine Corps	Clerical	NO CS PC WK	131	• Combined Scores
	Air Force	Administrative	NO CS PC WK	142	• Combined Scores
Technical	Army	Electronics	AR MK GS EI	175	• Combined Score
	Navy	Electronics	AR MK GS EI	156/212	MK+GS+EI=156(+AR=212)
	Marine Corps	Electronics	AR MK GS EI	182	• Combined Scores
	Air Force	Electronics	AR MK GS EI	181	• Combined Scores
	Army	General Mtnce	MK GS EI AS	177	• Combined Scores
	Marine Corps	General Mech	MK GS EI AS	N/A	• Not Applicable to Classif.
	Army	Skilled Technical	MK PC WK GS MC	178	• Combined Scores
	Navy	Skilled Technical	AR PC WK MC	146	• Combined Score with Multiple Rating-Specific Variations
	Marine Corps	Field Artillery	AR PC WK MC	139	• Combined Scores
	Navy	Nuclear	AR PC WK GS MK EI AS		
			AR PC WK	115	• Must meet all of these
			AR 2MK GS	200	qualifications
			AR MK GS EI	156/218	MK+GS+EI=156(+AR=218)
			MK AS	94	
Mechanical	Air Force	Mechanical	GS MC 2AS	173	• Combined Scores
	Navy	Mechanical Tech.	PC WK MC AS	145	• Combined Scores
Mechanical Maintenance	Army	Mech. Mtnce	AR EI MC AS	179	• Combined Scores
	Marine Corps	Mech. Mtnce	AR EI MC AS	167	• Combined Scores
Combat	Army	Field Artillery	AR MK CS MC	177	• Combined Scores
	Army	Combat	AR CS MC AS	178	• Combined Scores
Field	Marine Corps	Combat	NO PC WK AS	131	• Combined Scores
	Army	Operators/Food	NO PC WK MC AS	180	• Combined Scores
	Army	Surveillance/Comm	NO CS PC WK AS	191	• Combined Scores

*Minimum Score=Sum of Standard Scores

Exhibit B-6. DEFINITIONS OF MCR APTITUDE CLUSTERS

APPENDIX C

OVERVIEW OF THE EARLY-ON MANPOWER REQUIREMENTS ESTIMATION METHODOLOGY

This appendix describes the basic structure of the Early-on Manpower Requirements Estimation Methodology (EMREM). This discussion concentrates on the structure of the methodology.

The structure of the proposed manpower demand projection methodology is illustrated in Exhibit C-1. There are two major parts to the methodology, comprising a sequence of six analytical steps. These are:

Part A. Hardware Characterization

1. Identify Baseline Weapon System
2. Determine Baseline Weapon System Characteristics Changes
3. Develop New Weapon System Description

Part B. Manpower Requirements Estimation

1. Identify and Collect data on Manpower and Planned System Applications
2. Develop Manpower Estimates for New Weapon System
3. Translate Requirements into Aptitude Clusters

A brief description of the methodology is provided below.

A. HARDWARE CHARACTERIZATION

The first part of the methodology focuses on the identification of the hardware characteristics of the "new" system. By "new", we mean a weapon system concept that is being considered for acquisition and is the focus of the new design effort. The system may be required to face a completely new threat, replace an existing system or systems, or to exploit emerging technology. The need for the system is presented in its mission need statement.

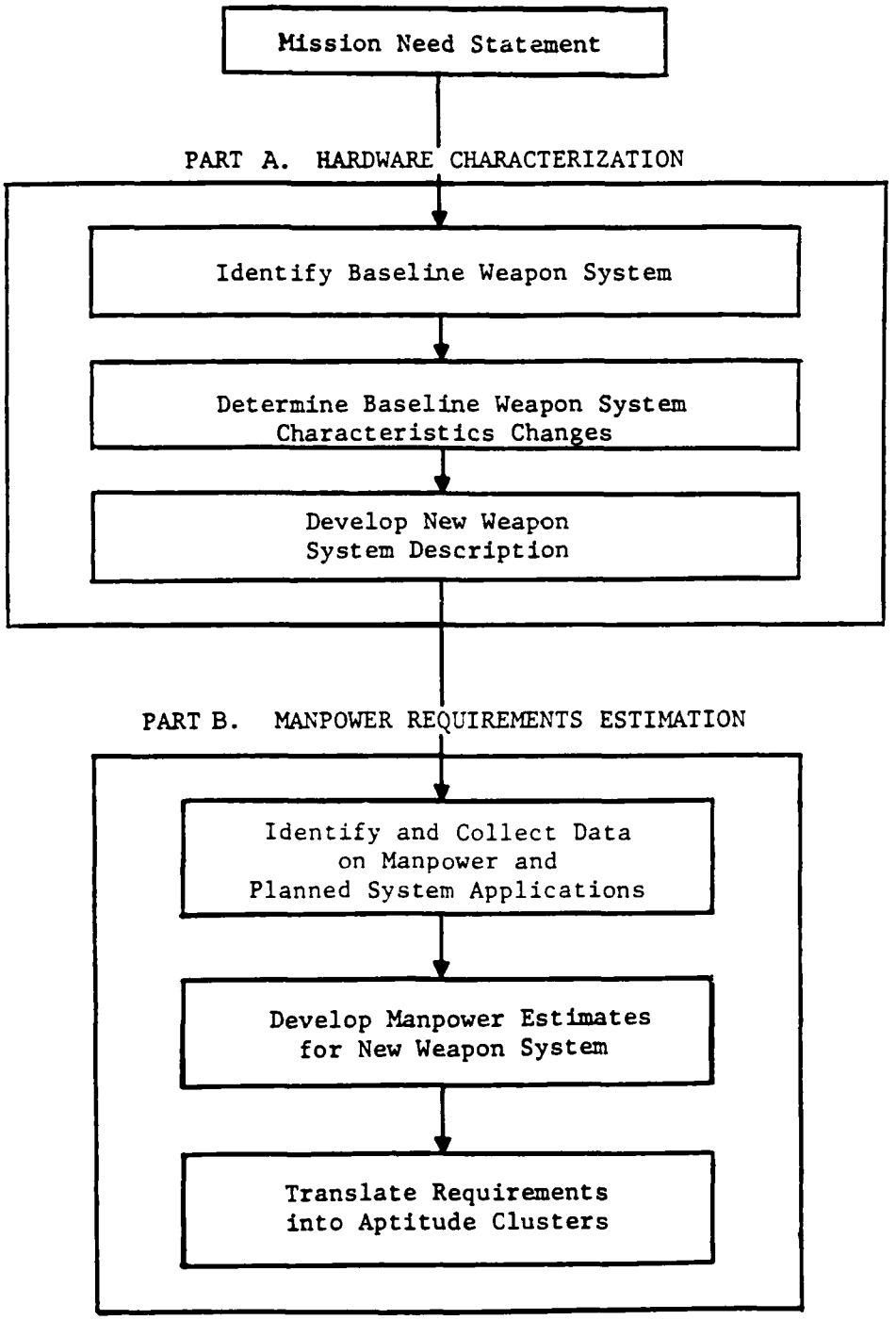

Exhibit C-1. SUMMARY OF THE EARLY-ON MANPOWER REQUIREMENTS ESTIMATION METHODOLOGY (EMREM)

As with the estimation of manpower requirements, the hardware characterization for the new system relies on comparability analysis. Planned characteristics for the new system are compared to characteristics of existing systems, with each subsystem examined largely independently. Most resource analysis early in the development of a weapon system design uses this approach to some extent. Current OSD policy in the form of MIL-STD-1388-1A, Logistic Support Analysis (April 1983), advocates the use of comparability analysis in developing early resource requirements estimates.

1. Identify the Baseline Weapon System

The baseline system[4/] is that system (or systems) already in the force structure which most closely relates to the design, performance, and support characteristics of the new system. That system is, in effect, the baseline from which new designs or concepts are evaluated.

The purpose of the baseline system is to establish a starting point for considering hardware characteristics and manpower data that may be extrapolated to the new system. In determining the baseline system, the objective is to achieve the most detailed description of performance parameters and hardware characteristics that can be developed from the mission need

4/ The reference to a single baseline system is made only to simplify the discussion. In actual practice, several systems or portions of several systems, representing specific capabilities required of the new system, may be used.

statement. This allows greater confidence in using the baseline system manpower requirements as an analog for establishing the new system manpower estimates.

2. Determine the Baseline Weapon System Characteristics Changes

Having identified the primary and any secondary baseline systems, which are to serve as the principal source of historical hardware and manpower data, it is important to isolate the elements of the baseline system that are shared with the new system. The basic approach taken in analyzing potential differences between the new and existing systems is to identify those hardware features of the baseline system that are inconsistent with the postulated mission need. These subsystems will be used as the basis for exploring the appropriateness of related manpower requirements in the development of the new system manpower estimate.

3. Develop New Weapon System Description

Having identified those characteristics of the baseline system that can be considered functionally similar to (or wholly in common with) the new system, the next step is to complete the hardware characteristics definition of the new system. That involves completing the list of new system subsystems and identifying subsystem functions that appear to require new or modified hardware.

It is possible that one or more of the new system requirements may have no functional relationship with any existing system or subsystem. These requirements can be classified as developmental, in that no baseline or in-service system data are available for any functional hardware. In these instances, a proxy for the system characteristic could be selected based on the perceived similarity of manpower requirements. Alternatively, additional analysis supplementing the main estimating effort could be performed to develop preliminary estimates for individual developmental subsystems. In any case, the historical data ultimately used may require tailoring to "fit" the new system. Information concerning the definition of the new system hardware characteristics, and the relationship of these to in-service and developmental subsystems, usually comes from system designers or other specialists.

The ultimate product of the first part of the EMREM methodology, the Hardware Characterization, is a description of the new system. This description is provided as a list of the set of subsystems contained in the system, associated with a general description of the performance parameters and operational requirements contained in the mission need statement.

The list of hardware characteristics developed in this part of the EMREM methodology acts as the guide for developing the manpower estimates in the next part of the analysis.

B. MANPOWER REQUIREMENTS ESTIMATION

The analysis as developed thus far lays the groundwork for developing an initial estimate of weapon system manpower requirements. For the purposes of this analysis, this involves determining the total number of enlisted operators (or crew) and enlisted below depot-level maintenance personnel required by the system. It is presented in the context of the organizational unit in which the system will be deployed.

The manpower estimate is developed in three steps, each of which is outlined below.

1. Identify and Collect Data on Manpower and Planned System Applications

In order to develop estimates of manpower requirements, a variety of data must be identified. Information on the planned operational environment, the general structure of the organizational unit, the number of systems to be assigned to organizational units, maintainability and repairability goals, and actual manpower data must be collected. The methodology largely relies on the use of historical manpower data for the baseline system for estimating maintenance manpower requirements. While estimates developed later in the design process can use planned system operational data to develop new system requirements estimates, very early manpower estimating must rely on adapting historical experience to the new application. (The reconstruction of an historical data file no longer intact presents additional concerns which are discussed later in this section.)

2. Develop Manpower Estimates for the New Weapon System

The hardware characterization developed for the new weapon system forms the basis for subsequently developing estimates of manpower requirements for that system. As explained in the discussion of the hardware characterization, the subsystems planned for the new system are related to those of the primary and secondary baseline systems. Subsystem functions common to both the new and baseline systems are identified after comparing the functional requirements (i.e., planned operational environment, usage rates, maintenance philosophy) of the new system to the baseline. Those subsystems not found to be similar to baseline subsystems are compared to other in-service systems. This analysis expands on the hardware characterization for the purpose of identifying the availability and appropriateness of historical manpower data. Ideally data should be in the form of maintenance manhours per operational hour or increment (e.g., flying hour, mile, etc.) or in a form which can be converted to this type of data for each subsystem. The historical manpower data adapted from the baselines will be used as the basis for developing subsystem manpower "modules" for the new system in the same way that hardware characteristic groups are developed in the first part of the methodology. There may, of course, be elements of the new system that have no direct analog in already operational equipment. A proxy for those functions must be identified

from the set of subsystems actually in the force structure in order to maximize (if possible) the use of historical manpower data.

The maintenance manpower requirements experience associated with those subsystems common to both the baseline and new weapon systems is discerned by examining the historical (actual) data on the baseline system. For those in-service subsystems, a similar approach is used. Attributable manpower requirements can be obtained by extrapolating, from other weapon systems. the maintenance experience peculiar to the new features.

Using the historical and derived manpower for each of the subsystems, an aggregate estimate of total enlisted below-depot-level maintenance and operator/crew manhour requirements is initially developed and then aggregated to manpower requirements. These manhour and manpower estimates are developed in terms of requirements for specific enlisted military occupations. In order to represent potential uncertainty in these estimates, ranges of requirements are generated. This is accomplished by changing the various input data, usually the usage rate. When possible, peacetime and wartime estimates have been developed by subsystem/occupation in order to demonstrate this capability (currently required in MIL-STD-1388-1A).

3. Translate Requirements into Aptitude Clusters

Having developed the set of new weapon system manpower estimates, the final step in the EMREM process is the translation of those estimates from military occupations to Aptitude Cluster

requirements. The purpose of this step is to present the requirements in terms compatible with MCR's proposed supply projection methodology. The Aptitude Clusters represent the aggregation of Service aptitude composites into a single set of seven groupings. The aptitude composites represent the capabilities the Services have determined to be most closely associated with their particular occupations. The definitions of the Aptitude Clusters are summarized in Appendix B.

END

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