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NAVMAN: A MODEL FOR ESTIMATING MAINTENANCE PERSONNEL REQUIREMEN--ETC(U)

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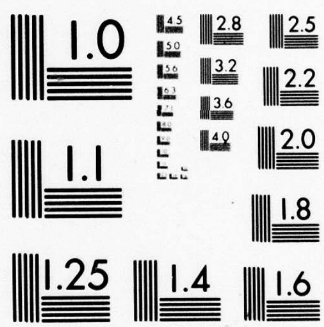

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NAVMAN: A Model for Estimating Maintenance Personnel Requirements for Navy Aircraft: Vol. I, Model Development and Application

B. Armstrong, J. Schank

A Report prepared for

OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE/
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This report describes a computer model developed at Rand for generating estimates of organizational and intermediate level maintenance personnel requirements for new U.S. Navy aircraft. NAVMAN provides a capability that does not currently exist for systematic estimation of personnel needs during the early stages of aircraft development (before information about subsystem-peculiar personnel factors are available in detail). The model provides (1) an analytic tool for estimation, (2) capability for assessment of estimates prepared by the military services, and (3) a means for systematic exploration of the effects of changes in certain system and maintenance policy variables on personnel requirements. This volume provides an overview of Navy personnel planning methods and of the model features (data requirements, assumptions, and reports). See also R-2402/2-PA&E (Technical Appendixes). 55 pp. (Author).

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PREFACE

This two-volume report describes NAVMAN, a computer model for generating estimates of organizational and intermediate-level maintenance personnel requirements for new U.S. Navy aircraft. NAVMAN incorporates into a single framework the diverse methods and factors used by the Navy to estimate below-depot level maintenance personnel requirements. It provides a means that does not now exist in systematic form to estimate these requirements during the early stages of system development--that is, before information about subsystem reliability and maintainability characteristics and other system-peculiar personnel factors is available in detail. Because NAVMAN builds on current Navy methods, it does not provide an independent assessment of what the personnel requirements *should* be. It does provide, however, a reliable approximation of what the detailed Navy methods will eventually generate as requirements.

The development of NAVMAN was sponsored by the Office of the Director of Cost and Economic Analysis, Office of the Assistant Secretary of Defense (Program Analysis and Evaluation). The model is intended primarily for use by Cost and Economic Analysis, and by the Cost Analysis Improvement Group (CAIG) that it chairs, in support of the Defense Systems Acquisition Review Council (DSARC). Among the responsibilities of CAIG and DSARC is critical review of the operating and support cost consequences of the acquisition of new weapon systems. Maintenance personnel requirements are primary contributors to operating and support costs; hence those requirements themselves draw critical review. NAVMAN and a similar model for Air Force tactical aircraft* provide CAIG with an analytic tool for estimating personnel requirements early in the acquisition review process, for assessing the reasonableness of estimates prepared by the military

*See W. S. Furry et al., *MANPOWER: A Model of Tactical Aircraft Maintenance Personnel Requirements: Vol. I, Overview of Model Development and Application; Vol. II, Technical Appendixes*, The Rand Corporation, R-2358/1,2-PA&E, April 1979.

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exploring the effects of changes in certain system and maintenance policy variables on those requirements.

In addition to its use by CAIG, NAVMAN should be helpful to U.S. Navy offices involved in aircraft system personnel determination processes. It should be of special interest to the HARDMAN Project Office, which is concerned with determining the timeliness of Navy personnel requirements. A major conclusion of the HARDMAN study* is that determination of personnel requirements occurs too late in the weapon system acquisition process and fails to address major issues of personnel tradeoffs. HARDMAN recommends developing and implementing analytical tools and models that can define maintenance personnel requirements during the early stages of weapon system development.

Volume I of this report, *Model Development and Application*, provides a complete overview of Navy personnel planning methods and of the features, input requirements, and outputs of NAVMAN. Volume II, *Technical Appendixes*, provides information on detailed model operation, model factors and variables, reliability and maintainability reference information, and a computer program listing.

The methods and factors incorporated in NAVMAN are current as of mid-1978. They are subject to modification, however, for the Navy personnel planning process is a dynamic one and is undergoing important changes. The user of NAVMAN should be aware of the need to update the model periodically.

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* *Military Manpower versus Hardware Procurement Study (HARDMAN), Final Report*, Chief of Naval Operations, United States Navy, October 1977.

SUMMARY

NAVMAN is a deterministic computer model, written in PL/1, which replicates the methods currently used in Navy personnel planning for aircraft in fleet service. The model provides estimates of below-depot level maintenance personnel requirements, both preventive and corrective, for new aircraft systems. Additionally, the model permits analysis of personnel requirement consequences caused by changes in the flying program, system reliability, maintainability, and other flying activities.

Maintenance support of Navy aircraft is accomplished at three levels--organizational, intermediate, and depot. NAVMAN projects personnel needs for organizational and intermediate maintenance. Organizational maintenance involves those functions performed by an operating unit on a day-to-day basis (i.e., on-equipment repair, inspection, servicing, and handling) while intermediate-level maintenance involves off-equipment repair of assemblies, testing and calibration, technical assistance, and manufacture of certain nonavailable parts. Organizational maintenance is an aircraft squadron function with permanently assigned personnel, whereas intermediate maintenance is a ship or Naval Air Station (NAS) group responsible for all aircraft and squadrons assigned to a carrier or NAS. NAVMAN necessarily treats these unique maintenance groups separately with specific and individual input parameters, equations, factors, and tables.

To use NAVMAN, the analyst must supply (1) operations information for both sea and shore environments (sortie rate, sortie length, and flying days per week); (2) organizational features (squadron size, number of squadrons, aircraft type, and number of work shifts); and (3) maintenance characteristics (maintenance manhours per flying hour, or per sortie, or mean time between failure and mean time to repair). Model outputs are reported in various formats--ship requirements and shore requirements, for each organization level, for the total fleet, individual squadrons, and work centers.

Technical appendixes (Volume II) describes in detail the operation of the model and present the variables, manning equations, factors, tables, and analytical assumptions used in the development of NAVMAN. Additionally, Volume II provides a program listing and some historical reliability and maintainability (R&M) information for Navy aircraft which may provide analysts with useful data points for evaluation by analogy.

Several steps might be taken to further strengthen and extend the NAVMAN model. The output of the model might be contrasted with Squadron Manning Documents (SQMDs) for which descriptive (input) data are available. This would provide a more thorough validation of NAVMAN than was permitted by the scope of the present research. Positive model extensions include making the number of squadrons a sensitivity variable; and developing a subroutine to generate work-center maintenance workloads as a function of a wide range of R&M inputs. Another improvement would be to substantially broaden the reference data base of historical R&M values and personnel requirements.

ACKNOWLEDGMENTS

Many persons have contributed to our understanding of the Navy maintenance organization and personnel requirements determination process. We are especially thankful to Lieutenant Commander Dale Huber of OP-124, Mr. John Cahoon of NAVMMACLANT, and Lieutenant Commander Cliff Graf of NAVMMACLANT. Without the time and insight of these people, we could not have performed the subsequent analyses.

The authors also express their appreciation for the technical assistance provided by Gerry Blais of the Washington office of Rand. Of course, the content and perceptions presented herein remain the sole responsibility of the authors.

CONTENTS

GLOSSARY

ACM-01	Work Center Staffing Standards--Aircraft Organizational Maintenance
ACM-02	Work Center Staffing Standards--Aircraft Intermediate Maintenance
AIMD	Aircraft Intermediate Maintenance Department
AM	Aircraft Maintenance
AS	Administrative Support
CAIG	Cost Analysis Improvement Group
CM	Corrective Maintenance
ConUS	Continental United States
DM	Directed Manning
DMMH/FH	Direct Maintenance Manhours per Flying Hour
DSARC	Defense Systems Acquisition Review Council
FM	Facilities Maintenance
GSE	Ground Support Equipment
M&O	Maintenance and Operations
MEA	Maintenance Engineering Analysis
MMH/FD	Maintenance Manhours per Flying Day
MMH/FH	Maintenance Manhours per Flying Hour
MMH/S	Maintenance Manhours per Sortie
MMH/W	Maintenance Manhours per Week
MRC	Maintenance Requirements Card
MR/PA	Make Ready/Put Away
MTBF	Mean Time between Failure
MTTR	Mean Time to Repair

NALC	Naval Aviation Logistics Command
NAS	Naval Air Station
NAVAIR	Naval Air Systems Command
NAVMMACLANT/PAC	Navy Manpower and Material Analysis Center, Atlantic and Pacific
NEC	Navy Enlistment Classification
OASD	Office of the Assistant Secretary of Defense
OM	Directed Manning
OPNAV	Naval Operations
OW	Officer Manning
PA	Productive Allowance
PA&E	Program Analysis and Evaluation
PD	Productive Delay
PM	Preventive Maintenance
R&M	Reliability and Maintainability
SM	Support Maintenance (Equipment)
SQMD	Squadron Manning Document
TAD	Temporary Assigned Duty
TM	Total Maintenance (PM + CM)
UE	Unit Equipment (number of aircraft per squadron)
UT	Utilities Task
WC	Work Center
WM	Total Work Center Manhours
WSPPD	Weapon System Personnel Planning Document
WUC	Work Unit Code

I. INTRODUCTION

This report describes NAVMAN, a deterministic PL/1 computer model that estimates below-depot level maintenance personnel requirements for Navy aircraft. It is designed for application to new aircraft systems and permits analysis of personnel requirement modifications caused by changes in the flying program, system reliability and maintainability (R&M), and squadron organization. It is primarily intended for use during the early, concept development stages of system acquisition and utilizes simple, readily available data as inputs.

NAVMAN was developed to aid the Cost Analysis Improvement Group (CAIG) in making and evaluating cost and personnel estimates for new aircraft systems.* Because maintenance personnel is a significant contributor to the total operating and support cost of an aircraft, it is important to consider the personnel implications of new aircraft as early as possible in the acquisition process. Typically, these early estimates have been based on aggregate figures such as total direct maintenance manhours per flying hour. However, system reliability is only one of a number of variables that affect the level of maintenance personnel required, and the use of such gross statistics fails to provide visibility of the plausible personnel implications of an operational fleet of a new aircraft. Furthermore, a significant problem with the traditional R&M measures is the implicit assumption (often erroneous) that any improvement on one of the R&M dimensions will reduce personnel requirements. This assumption is not always valid because it ignores the significant effect on personnel requirements of such factors as operational unit size, the rate of use of the weapon system, maintenance crew-size requirements, shift coverage requirements, and the organization of occupational specialities. In short, the importance of organizational and program factors for personnel requirements often has been overlooked in the effort to reduce personnel by improving hardware R&M.

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*The CAIG provides cost information to the Defense Systems Acquisition Review Council (DSARC) for use in acquisition decisionmaking.

NAVMAN utilizes organization structure, flying program, and R&M inputs to calculate the scheduled and unscheduled maintenance workloads for each work center or shop. Indirect hours for administrative support, facilities maintenance, and other nonaircraft maintenance activities are added to the direct maintenance workloads to arrive at the total manhours required in each work center. Total hours are converted to personnel requirements on the basis of the appropriate manhour availability, and rating or skill-level requirements are determined from historical paygrade matrices. Administrative, supervision, and other nonmaintenance work centers are manned on the basis of equations that relate requirements to various independent variables such as flying hours, number of aircraft, or number of work orders processed. The resulting personnel requirements are presented at various levels of detail including total for the fleet of aircraft, per squadron, and by work center for both the sea and shore environments.

NAVMAN is based on the current Navy methods and factors contained in the OP-124 Squadron Manning Document Model* (organizational level maintenance) and the ACM-02 Model† (intermediate-level maintenance). Both of these Navy models are applied after an aircraft has been in the operational inventory for approximately a year so that sufficient historical data exist to project personnel requirements. Because NAVMAN is intended for use during the early stages of an aircraft's development when detailed data, especially subsystem R&M information, may not be available, the model was designed to accept a wide range of input data and to perform sensitivity analyses on the personnel requirements caused by changes in the flying program and the R&M parameters.

NAVMAN is based on current Navy methods and factors for determining maintenance personnel requirements; as such, the model does not provide an independent assessment of personnel for the CAIG. The model

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Squadron Manpower Requirements Determination Methodology, Chief of Naval Operations (OP-124F), Navy Department, Washington, D.C., 20350.

†*Work Center Staffing Standards: Aircraft Maintenance--Perform Intermediate Aircraft Maintenance--ACM-02*, NAVMMACLANT, January 13, 1978.

does provide an early estimate of personnel needs at a level of detail that enables the CAIG and/or PA&E to examine the validity of Navy personnel estimates and the effect on these estimates of changes in the operational and reliability parameters.

Personnel planning in all the services is a dynamic process. Work activities, missions, system characteristics and performance, organizations, and technology are constantly changing. These changes undoubtedly affect personnel utilization and strength requirements that are part of the current NAVMAN process. The using agencies must continuously update the model according to changes in Navy methods to ensure the validity of the model product. For example, as this report is being written, the Navy is in the process of revising its standards and methods for determining intermediate-level maintenance personnel (published as Navy document ACM-02). The variables and factors that are changed as a result of this revision must be incorporated into NAVMAN equations and factors to produce results consistent with Navy estimates.

The subsequent sections of this volume are organized to provide an overview of the model, its development and application. Section II summarizes the Navy's maintenance personnel estimation methods at various stages of an aircraft's development and operation. Section III presents an overview of the model operation and briefly describes the key model features, inputs, and outputs. Section IV outlines the input requirements necessary to run the model and describes the various output reports. It also presents an example run of the NAVMAN model. Finally, Section V discusses possible next steps for further testing and extension of the model.

Volume II of this report supplies specific model information. Included in the technical appendixes of that volume is a detailed description of the model operation and listings of the model variables factors and paygrade matrices. Volume II also contains a computer listing of NAVMAN and historical Navy aircraft maintenance data which may provide useful information in determining certain inputs.

II. CURRENT NAVY MAINTENANCE STRUCTURE AND METHODS FOR ESTIMATING MAINTENANCE PERSONNEL REQUIREMENTS

OPERATING ENVIRONMENT OF NAVY AIRCRAFT

Navy aircraft operate primarily in two environments*--on land at Naval Air Stations (NASs) and at sea on board aircraft carriers. All NASs in the ConUS are located on either the Atlantic or Pacific coast with one station on each coast designated as the home base for all aircraft of a given type (fighter, light attack, heavy attack). For example, all Navy fighter aircraft (F-14, F-4, and, in the near future, the F-18) are stationed at Miramar NAS on the West Coast and Oceana NAS on the East Coast. Current Navy aircraft and their respective squadron sizes are shown in Table 1.

Table 1

TYPICAL NAVY AIRCRAFT SQUADRONS

Aircraft	Mission	Squadron Size
F-4J	Fighter	12 aircraft
F-14A	Fighter	12 aircraft
A-7E	Light attack	12 aircraft
A-6E/KA-6D	Heavy attack/tanker	10/4 aircraft
EA-6B	Electronics	4 aircraft
E-2B	Electronics	4 aircraft
S-3A	Antisubmarine	10 aircraft
P-3C	Antisubmarine	9 aircraft

Squadrons are rotated during peacetime from the NASs to duty at sea on board the aircraft carriers. Depending on the class of the vessel, a carrier will have assigned to it between 70 and 100 aircraft. Typically there will be 2 or 3 squadrons of fighters, 2 squadrons of

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*An exception is the antisubmarine P-3 patrol aircraft. These aircraft are land-based and may deploy to various locations to perform their mission (termed VP-deployed).

light attack, 1 heavy attack squadron, and assorted numbers of reconnaissance, antisubmarine, and electronic warfare aircraft and helicopters.

ORGANIZATIONAL MAINTENANCE

Maintenance to support Navy aircraft is accomplished at three levels--organizational, intermediate, and depot. Organizational-level (O-level) maintenance involves those functions performed by an operating unit on a day-to-day basis in support of its own operations and includes:

1. Equipment inspections.
2. Equipment servicing.
3. Equipment handling.
4. On-equipment repair and "on-equipment" removal and replacement of defective parts and components.
5. Incorporation of designated technical directiveness.
6. The keeping of necessary records and reports peculiar to organizational-level maintenance.

To perform these functions, a squadron's organizational maintenance department is configured as shown in Fig. 1. Most of the functional areas indicated by the work centers in Fig. 1 are self-explanatory. The plane captains (work center 310) act as crew chiefs for specific aircraft. They take care of preflight and postflight inspections, fuel, oil, and clean the aircraft, strap the pilot in, and, in general, perform detailed visual inspections.

The troubleshooter group (work center 320) is composed of a number of highly skilled flight deck personnel whose technical experience enables them to identify which of a group of equipment may be malfunctioning. They also perform minor on-equipment repair.

Personnel of the weapons branch (work center 230) perform the scheduled and unscheduled on-equipment maintenance of the aircraft's weapon control and delivery systems and perform the uploading of munitions onto the aircraft. The maintenance and inspections of the

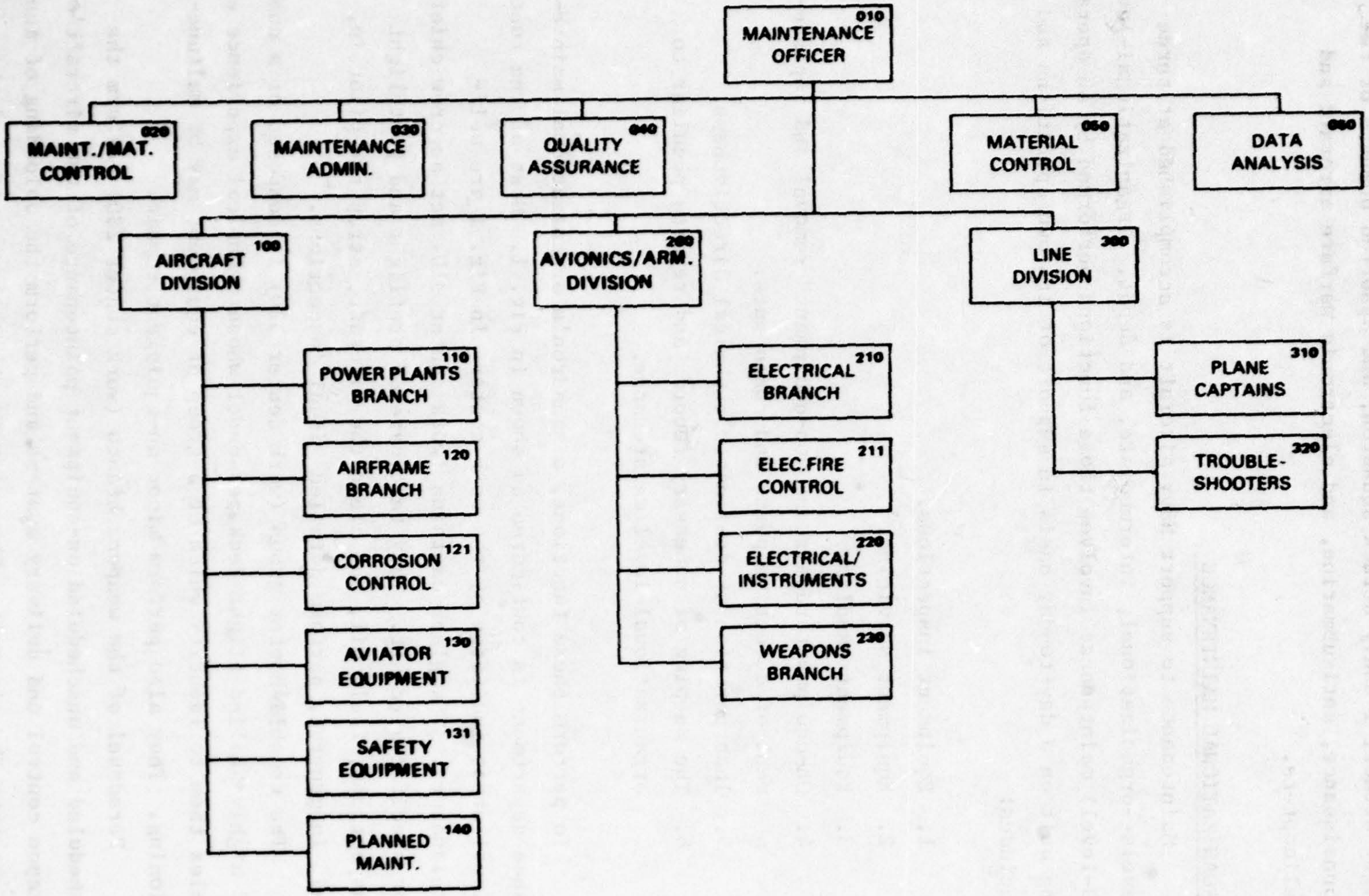


Fig. 1 — Navy organizational maintenance structure

munitions themselves are functions of the aircraft carrier or the NAS. Munitions are taken from the magazine areas and transported (by carrier or NAS personnel) to the flight line where they are uploaded by personnel from the aircraft's weapons work center.

Organizational maintenance personnel requirements for current Navy aircraft, as defined by the aircraft's Squadron Manning Documents (SQMDs), are shown in Table 2. It can be seen that not all work centers are manned for all aircraft. For example, work center 211, Electronic Fire Control, is manned only for fighter and attack aircraft. Also, the troubleshooters' work center (320) is not manned for shore-based aircraft (P-3C) or for squadrons with little troubleshooting workload. For these aircraft, any workload usually charged to work center 320 is spread among the other appropriate work centers.

INTERMEDIATE MAINTENANCE

Intermediate-level (I-level) maintenance includes:

1. Off-equipment repair or replacement of damaged or unserviceable parts, components, or assemblies.
2. The manufacture of certain nonavailable parts.
3. Calibration of designated equipment.
4. Providing technical assistance to the supported units.
5. Incorporation of designated technical directives.
6. The necessary record keeping and reports peculiar to intermediate-level maintenance.

Figures 2 and 3 show the intermediate-level organizations for units both ashore and afloat.

Unlike organizational maintenance that is an aircraft squadron function with personnel permanently assigned to the squadron, intermediate maintenance is a ship or NAS organization with responsibility for all aircraft and squadrons assigned to the carrier or the NAS. A cadre of maintenance personnel are permanently assigned to the Aircraft Intermediate Maintenance Department (AIMD) on board each aircraft carrier and at every NAS. These personnel maintain the intermediate

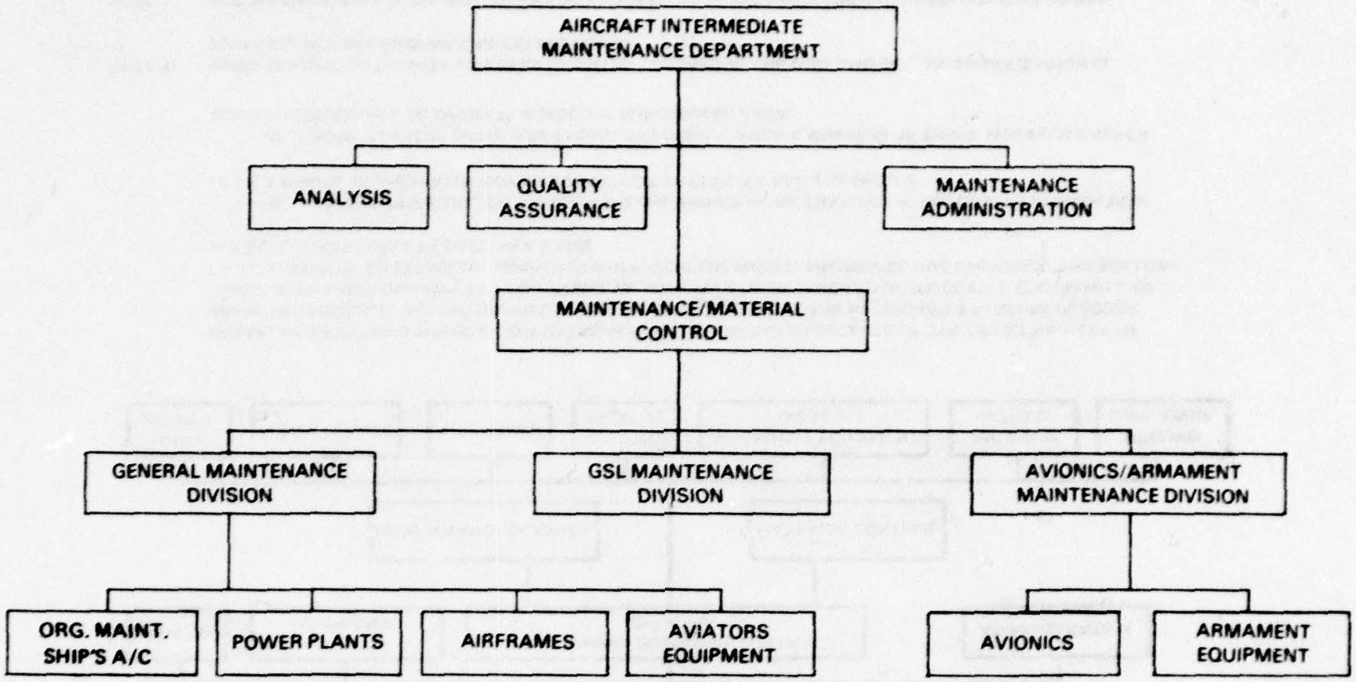
Table 2

MAINTENANCE PERSONNEL REQUIREMENTS FOR CURRENT NAVY AIRCRAFT SQUADRONS

Work Center	S-3A (10)[a]	A-6E/KA-6D (10/4)	EA-6B (4)	P-3C (9)	E-2B (4)	F-14A (12)	A-7E (12)	F-4J (12)
010 Maint. Officer	2	3	2	7	2	2	2	2
020 Maint./Mat. Control	8	8	7	9	8	7	7	9
030 Maint. Administration	2	1	1	1	1	1	2	1
040 Quality Assurance	9	10	9	8	7	10	9	9
050 Material Control	4	4	4	9	4	5	2	3
060 Data Analysis	2	1	1	1	1	1	1	1
100 Aircraft Division	3	2	--	3	2	2	2	2
110 Power Plants	14	18	16	13	12	16	10	13
120 Airframe	20	22	15	13	15	18	20	21
121 Corrosion Control	8	8	6	5	4	10	4	10
130 Aviator Equipment	7	4	2	3	2	3	3	4
131 Safety Equipment	10	7	6	4	5	9	8	7
140 Planned Maintenance	1	2	1	2	--	1	1	2
200 Avionics/Arm. Division	3	3	2	3	2	2	2	2
210 Electrical	23	12	33	12	16	15	13	11
211 Electronic Fire Control	--	12	--	--	--	16	14	14
220 Electrical/Instruments	24	15	13	9	9	18	10	15
230 Weapons	11	24	3	6	--	15	27	20
300 Line Division	2	2	--	2	2	2	1	2
310 Plane Captains	24	36	15	10	10	26	25	28
320 Troubleshooters	--	6	--	--	--	5	5	6
Total organizational	177	200	136	120	102	184	168	182
Squadron intermediate maintenance personnel	37	46	38	30	25	39	26	25

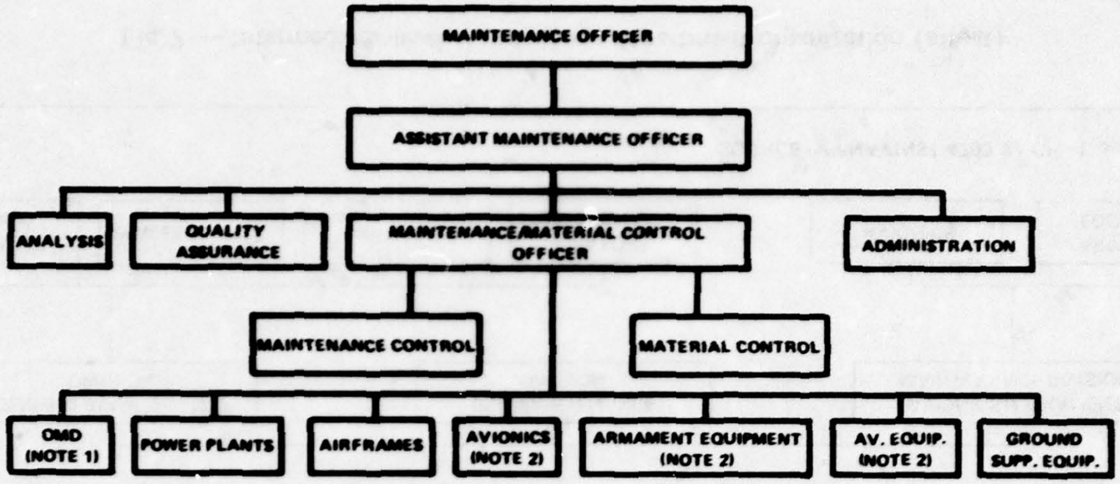
SOURCE: The appropriate aircraft's Squadron Manning Document.

[a]Number of aircraft per squadron.



SOURCE: OPNAVINST 4790.2A CH-1, June 11, 1974.

Fig. 2 — Intermediate-level maintenance department organization (afloat)



BREAKDOWNS BEYOND THE BASIC DIVISIONS ARE NOT ILLUSTRATED BECAUSE OF THE GREAT VARIETY OF BRANCHES POSSIBLE. ACTIVITIES WILL BE REQUIRED TO ESTABLISH THE NECESSARY BRANCHES IN ACCORDANCE WITH THEIR INDIVIDUAL REQUIREMENTS. APPENDIX "D" (STANDARD WORK CENTER CODES) WILL BE USED AS A GUIDE TO ESTABLISH BRANCHES/WORK CENTERS WITHIN THE RESPECTIVE DIVISIONS. THE FOLLOWING GUIDELINES SHALL BE USED AS A BASIS:

(A) BRANCHES SHOULD BE ESTABLISHED ONLY WHEN MORE THAN ONE WORK CENTER IS INVOLVED, I.E., JET ENGINE BRANCH WITH WORK CENTERS FOR J-79 ENGINE AND J-52 ENGINE.

(B) WORK CENTERS SHOULD BE ESTABLISHED ONLY WHEN A MINIMUM OF THREE MEN PLUS A SUPERVISOR ARE REQUIRED TO OPERATE A SPECIFIC FUNCTIONAL AREA.

NOTE 1: WHEN SPECIFIC AUTHORITY HAS BEEN GRANTED TO COMBINE THE OMD AND IMA, AN ORGANIZATIONAL MAINTENANCE DIVISION WILL BE ESTABLISHED.

NOTE 2: FOR MARINE CORPS ACTIVITIES, OFFICERS ASSIGNED TO THESE DIVISIONS HAVE GROUP DUTIES UNDER THE COORDINATION OF THE GROUP MAINTENANCE OFFICER.

SOURCE: OPNAVINST 4790.2A, Vol. 1, June 18, 1973.

Fig. 3 — Intermediate-level maintenance department organization (ashore)

benches and equipment, perform some general maintenance, and provide administrative and staff-level functions.

The permanent ship or shore cadre is augmented by intermediate maintenance personnel assigned from the squadrons. When a carrier goes to sea, the AIMD on board the ship must satisfy the intermediate maintenance requirements of all the aircraft assigned to the carrier. To satisfy these requirements, each squadron sends a number of Temporary Assigned Duty (TAD) personnel to the AIMD. The numbers and types of these TAD personnel depend on the intermediate maintenance requirements of the squadron and the workload and capabilities of the AIMD cadre. Before going to sea, the intermediate maintenance officers determine which intermediate maintenance requirements will be temporarily satisfied by each squadron. Personnel from one squadron may, therefore, perform intermediate-level maintenance for aircraft of another squadron. The same temporary assignment of personnel to the intermediate shops also occurs when a squadron transitions from sea to a NAS. Table 2 also shows I-level TAD personnel assigned to current Navy squadrons.

The Navy currently estimates maintenance personnel requirements both before and after an aircraft enters the operational inventory. The next section describes the methods used by the Naval Aviation Logistics Command and the Navy Manpower and Material Analysis Center Atlantic and Pacific in developing their individual personnel reports.

MAINTENANCE PERSONNEL ESTIMATION BEFORE AIRCRAFT DEVELOPMENT

The first attempt to estimate personnel requirements is made by the Navy during the preparation of aircraft specifications--long before full-scale development and prototype production. The estimate is published in the form of the maximum direct maintenance manhours per flying hours (DMMH/FH). This DMMH/FH approximation is based on historical maintenance data for similar aircraft or aircraft subsystems. Knowledge of new equipment requirements, personnel constraints, and anticipated reductions in maintenance requirements are used to adjust the current experience. The aircraft contractors receive this DMMH/FH goal in the initial Request for Proposal (RFP) issued by the Navy.

In preparation of the proposal, the aerospace industry closely examines the personnel requirements associated with its aircraft design. The hardware contractor's Logistics Analysis and Operations Analysis divisions prepare detailed estimates of squadron personnel by skill type and skill level. This effort is published in the Weapon System Personnel Planning Document submitted to the Navy with the production proposal. Although on the surface this would appear to be the first in-depth examination of requirements, it is unfortunately biased by the DMMH/FH goal stated in the RFP. That is, the contractor, in his natural zeal to be awarded the development and production contract, uses the DMMH/FH goal as a target in the estimation of R&M characteristics of his proposed equipment.

The first detailed Navy estimate of the quantitative and qualitative maintenance personnel requirements are made by personnel of the Naval Aviation Logistics Command (NALC--formerly Naval Aviation Integrated Logistics Support Command, NAILSC). This estimate is prepared 4 to 6 months after the contract award for full-scale development and, therefore, after DSARC II. In forming the Maintenance and Operating (M&O) Report, NALC analysts use the historical maintenance data (3M files*) for similar aircraft and subsystems as well as contractor Maintenance Engineering Analyses and opinions of subsystem operations experts (primarily chief petty officers). This objective NALC estimate, typically reported in terms of DMMH/FH, must be reconciled with the previous Navy DMMH/FH goal and the contractor estimates. As a result, some of the objectivity is ultimately lost.

As system development progresses, designs become more firmly defined and test data yield better visibility of R&M. With the additional data and experience gained through testing, the NALC prepares its second and final M&O report approximately 6 months to a year before service introduction. Both NALC reports feed into the Five Year Defense Plan and into the Personnel and Training systems to ensure that

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*The "3M" file is a maintenance and material utilization data system managed by the Navy Fleet Material Support Office in Mechanicsburg, Penn.

sufficient quantities of the properly skilled personnel are available when the aircraft reaches the fleet.

NALC analysts are usually highly experienced in the aircraft maintenance environment and use their knowledge as subjective inputs to the prediction process. Using contractor and 3M data, they first formulate the DMMH/FH. This value includes all direct maintenance and inspection requirements. It does not include indirect, transit, access, or similar "non-wrench turning" times. Those actions or subsystems that are not related to flying hours (such as calendar inspections, landing gear, wheels and tires, etc.) are translated into flying-hour values on the basis of monthly utilization, sorties, and flying hours per sortie. The assumption is made that operating time equals flight time for all equipment. NALC personnel then segregate the total DMMH/FH into requirements for each type of maintenance skill by work center. To arrive at manning requirements, the following equation is used:

$$\frac{(\text{DMMH/FH})(\text{FH per month})(\text{K factor})(\text{AC/SQ})}{120 \text{ hours/month}} .$$

The flying-hour factor is a monthly average of carrier and NAS requirements developed by OPNAV and NAVAIR. The K factor accounts for the indirect hours and translates direct maintenance hours to productive hours. The values are 1.82 if contractor information is being used for the DMMH/FH term and 1.19 if the DMMH/FH term is based on 3M data.* The 120 hours per month is an availability factor used exclusively by the NALC.

The above manning equation is used to determine direct maintenance requirements by functional rating for organizational and intermediate levels. Supervisory positions, management and staff duties, and certain work centers are position-manned on the basis of values

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*The number is higher for contractor values because such values are usually measured in a test environment with skilled technicians and all access panels opened. The 3M data include transit, access, and other indirect items.

in ACM-01 (Aircraft Organizational Maintenance Staffing Standards) and the analysts' subjective judgment. From the Navy Enlistment Classification (NEC) manual (NAVPERS 18068D), the NALC analyst can determine which specialization codes are appropriate for the derived skill need. If a suitable code does not exist because of the introduction of new equipment, the NALC can recommend the establishment of a new code and outline the requirements and necessary methods of instruction. If possible, fractional requirements* are often combined so that one person with several applicable specialization codes may be responsible for the maintenance of multiple equipment.

PERSONNEL ESTIMATION AFTER SERVICE INTRODUCTION: ORGANIZATIONAL LEVEL

Approximately one year after a new aircraft system becomes operational, the Aviation Squadron Manning Requirements Section (OP-124F) creates the final maintenance personnel document--the SQMD. OP-124 is assisted in this effort by personnel survey teams at the Navy Manpower and Material Analysis Centers, Atlantic and Pacific (Norfolk, Va., and San Diego, Calif.) (NAVMMACLANT and PAC). These teams visit each squadron to validate the personnel requirements in the SQMD. The OP-124 methodology is similar to that of NALC in that personnel requirements are determined from workload and personnel availability. However, OP-124 uses actual maintenance data from the 3M reporting system instead of contractor estimates or analagous system data and considers other types of workload in addition to direct maintenance hours. OP-124 considers only a shipboard environment.

In the OP-124 model, workload is categorized as preventive maintenance (PM), corrective maintenance (CM), administrative support (AS), facilities maintenance (FM), utilities task (UT), directed manning (DM), or officer manning (OW).†

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*Fractional values less than .24 are truncated unless the value is less than 1.0, in which case one person is assigned.

†OW hours represent the aircraft pilots and crew who are assigned to flight operations and duties. These personnel are placed in the maintenance complex to provide them with an understanding of activities and a career progression path. The pilots and other aircrew members are not considered in NAVMAN.

PM includes all aircraft scheduled maintenance activities. The actual workload data are collected from Maintenance Requirements Cards (MRCs) for each type and model of aircraft. These MRCs describe the time required and the types of personnel necessary to accomplish the scheduled maintenance on operational equipment, components, and systems. The PM workload is divided into the following categories:

1. PM hours per aircraft per week.
2. PM hours per aircraft per (flying) day.
3. PM hours per aircraft per sortie.
4. PM hours per aircraft per flight hour.

Using the appropriate values from the aircraft's Required Operational Capabilities and Projected Operational Environment, the total direct PM workload is calculated for each work center and for the appropriate skills and ratings.

CM includes the aircraft unscheduled maintenance activities. The workload data are derived from historical 3M data obtained from the Maintenance Supportive Office Department. The CM workload is broken into Maintenance Action Forms (MAFs) and Support Action Forms (SAFs), and each component is statistically regressed to form predictive equations that make it possible to determine the total workload at any level of flight activity. The exponential form is used for the regression equation on the assumption that as flight hours increase, manhours per flight hour decrease. In addition to the regression equation, ratios are developed that determine how much of a squadron's total MAF and SAF workload is appropriate for each work center.

The PM and CM hours usually account for only the direct workload. Factors are added to account for the indirect time associated with the maintenance actions. These indirect categories include:

1. Productive Delay (PD)--An allowance to reflect delays caused by awaiting the arrival of parts, awaiting transportation, inclement weather, awaiting deck space, changing work areas, etc. The PD factors ranged from 5 to 35 percent and vary by work center and environment.

2. Productive Allowance (PA)--An allowance for delays arising from fatigue, environmental effects, personal needs, and unavoidable interruptions. PA is a 20 percent factor.
3. Make Ready/Put Away (MR/PA)--An allowance for the time required to open the appropriate area of the aircraft, requisition any necessary tools or equipment, and secure the aircraft when the work is completed. The MR/PA factor is 30 percent.

The total PM workload is computed as

$$\text{Total PM} = [\text{Raw PM} \times (1 + \text{MR/PA})][1 + (\text{PA} + \text{PD})],$$

whereas the total CM workload is

$$\text{Total CM} = [\text{Raw CM}][1 + \text{PD}].$$

MR/PA and PA factors are not considered for CM because the 3M system is designed to collect these indirect hours.

On completion of the total maintenance workload calculation (PM + CM), hours are added for AS, FM, and UT. AS hours include supervision and clerical, instructional, and administrative functions. The calculation of total AS hours is based on a ratio of total CM and PM hours as follows:

$$\text{Total AS} = A + B(\text{PM} + \text{CM}),$$

where A and B vary by environment. The total workload is then allocated to the various work centers on a percentage basis.

FM hours provide for the routine housekeeping of assigned living, working, and operating areas and are calculated as a percentage of each work center's AS workload:

$$\text{Work Center FM} = (\text{Work Center AS})(\text{Work Center FM\%}).$$

The FM percentages were determined through work measurement techniques and vary by work center.

UT hours represent the workload assigned to carrier-based squadrons for working groups to augment ships' personnel in performing underway replenishment operations. The quantity of UT hours is determined by operational audit techniques and is added to the work center's workload. UT hours apply only to carrier operations.

OW workload are those hours associated with administrative duties and flight operations of the crew members. OM hours are those required to man time-constrained stations associated with flight operations and watches, either carrier or shore-based. These hours are usually applicable to the plane captains, troubleshooters, and security work centers and integrity watches.

After the total workload is calculated for each work center, personnel requirements are computed by dividing by the appropriate personnel availabilities. The standard work weeks used in this calculation are

Shore-based: 31.9 productive hours out of a 40-hour week
VP-deployed:* 51.0 productive hours out of a 57-hour week
Carrier-based: 63.0 productive hours out of a 70-hour week

Fractional personnel values are then rounded to whole persons according to specified cutoff values. Work-center personnel are distributed among paygrades (E-2 to E-9) using an authorization level/paygrade matrix developed from the BUPERS Occupational Classification System, derived paygrades as estimated through operational audit techniques, and the OSD "top-six" guidelines.

The above procedures apply for the maintenance work centers. Overhead, administrative, and analysis work centers are manned on the basis of equations that relate personnel or manhours to variables such as number of flying hours, number of aircraft, or number of requisitions processed.

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*"VP-deployed" represents shore-based squadrons deployed to overseas bases.

The maintenance personnel requirements computed by OP-124 are published as OPNAV instructions and serve as a basis for requesting funding throughout the budget cycle.

PERSONNEL ESTIMATION AFTER SERVICE INTRODUCTION: INTERMEDIATE LEVEL

The AIMD, as previously stated, is staffed with a permanent cadre of ship or station personnel augmented by TAD maintenance personnel from the individual squadrons supported by the facility.

The management work centers (OXX), the production division offices (XOO), the Ground Support Equipment Division (9XX), and certain other work centers (i.e., Precision Measurement Equipment) are staffed with ship or station personnel. The production work centers are staffed primarily with TAD persons and a small cadre of permanent staff.

The Navy has developed and recently published a revised method for determining intermediate-level maintenance personnel requirements. This publication, called ACM-02,* defines work-center staffing methods for production work centers as well as management and support work centers.

The standard equations for the OM (overhead, analysis, supervision) work centers are typically a function of the number of aircraft supported, the number of subordinate work centers, or the support equipment workload.

Personnel requirements for the production work centers are determined from the numbers and types of each aircraft maintained by the facility. For each aircraft type (F-14, S-3A, etc.), ACM-02 provides a monthly intermediate-level maintenance manhours estimate called a "b-value." The b-value is multiplied by the number of aircraft of that type assigned to the AIMD to determine the total maintenance manhour requirements.

The total maintenance manhours are then allocated to the individual work centers using a "Z table" derived from historical maintenance

Work Center Staffing Standards: Aircraft Maintenance--Perform Intermediate Aircraft Maintenance--ACM-02, NAVMMACLANT, January 13, 1978.

data (3M). A "Z-table" is derived for each AIMD location by type, model, and series of aircraft. Table 3 shows the Z-value table foı Miramar intermediate maintenance.

Support Maintenance (SM) manhours for scheduled and unscheduled maintenance of support equipment (i.e., test sets) are added to the total aircraft maintenance manhours (AM). Because support equipment, as a general rule, cannot be directly associated with an aircraft, ACM-02 presents a table that lists SM manhour additives by work center and location. Table 4 gives an example of such a table for the Jet Engine Shop.

The total work-center manhours (WM)* are then divided by the available hours during the work week to determine the number of work-center billets.

To determine the required AS manhours, the number of work-center billets is multiplied by a constant coefficient derived from operational audit measurements and regression analysis.

Finally, AS manhours are added to WM manhours to arrive at total maintenance manhours (TM). By dividing TM by the appropriate Navy work week (based on the environment in which the work is performed),† TM is converted to billets.

The number of intermediate maintenance-level TAD personnel required for a squadron (and reflected in the SQMD) is determined for a ship environment. The maintenance demands of each squadron are viewed in isolation, and if there are multiple squadrons of the same type of aircraft assigned to a carrier (F-14, F-4, A-7), each squadron receives the same number and type of TAD personnel.

The methods and factors embodied in the OP-124 (organizational-level) and the ACM-02 (intermediate-level) models serve as the

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*WM = AM + SM.

†For intermediate maintenance, the standard work weeks are

Shore-based: 31.9 productive hours
Carrier-based: 60.0 productive hours

Table 3

ACTIVITY Z TABLE: MIRAMAR

Work Center Number	Work Center Title	Aircraft												
		A-4E	A-4F	TA-4J	C-1A	E-2B	TE-2A	F-4J	F-4N	F-5E	RF-8G	F-14A	T-288	T-38A
9	Jet Engine	.2077	.2924	.3221		.1823	.3143	.2134	.1996		.3852	.2302		.0019
10	Reciprocating Engine													
11	Propeller					.0076	.0375							
12	Rotor													
13	Test Cell	.0692	.0278	.0642				.0302	.0116	.0185	.0122	.0479		
14	Auxiliary Fuel Stores													
16	Structures	.0677	.0432	.0534	.0397	.0238	.0512	.0220	.0161	.0058	.0264	.0617	.1269	.0027
17	Machine	.0081	.0028	.0058		.0020		.0022	.0023		.0004	.0023		
18	Paint	.0096	.0145	.0197		.0092	.0191	.0092	.0178	.0230	.0080	.0044	.0443	
19	Hydraulic/Pneumatic	.0516	.0508	.0420	.1236	.0300	.0880	.0515	.0766	.0302	.0712	.0238	.0439	.0800
20	Tire/Wheel	.1017	.1214	.1055	.0750	.0169	.0755	.0557	.0996	.1394	.0292	.0204	.0230	.0380
21	Welding	.0015	.0021	.0052		.0005	.0036	.0051	.0128	.0151	.0029	.0103		.0013
22	Nondestruct Testing	.0373	.0066	.0061	.0044	.0057	.0109	.0139	.0140	.3823	.0082	.0078	.0027	.3531
23	Oil Analysis													
25	COMM/NAV	.1867	.2093	.1868	.3798	.1792	.2019	.1049	.1254	.0988	.1484	.0225	.4180	.1184
26	Electrical/Instrument	.1553	.1037	.1352	.0849	.0452	.0603	.1603	.1270	.1317	.1200	.0252	.0727	.0774
27	Fire Control			.0003		.0002		.2057	.1510		.0094	.1627		
28	Radar/ECM		.0118	.0006		.0834	.0029	.0278	.0459		.1243	.0419		
29	SACE/Inert. Navigation					.3114	.1235	.0006				.0527		
30	Vast											.0935		
31	ASW													
32	PME													
33	Photo/Recon.													
34	Module Repair	.0143	.0047	.0033		.0373	.0020	.0298	.0152		.0071	.1011	.0041	
36	Aviation Ordnance	.0349	.0507	.0062				.0402	.0424			.0448		
37	Special Weapons													
39	Parachute/Floatation	.0164	.0073	.0131	.0234	.0255		.0105	.0171	.1459	.0133	.0182	.0209	.0346
40	Escape/Environmental					.0217		.0024						
41	Oxygen/Hydrogen	.0380	.0509	.0305		.0181	.0093	.0146	.0256	.0093	.0338	.0286	.0013	.2926

SOURCE: *Work Center Staffing Standards: Aircraft Maintenance--Perform Intermediate Aircraft Maintenance--ACM-02*, NAVMMACLANT, January 13, 1978.

Table 4

SUPPORT MAINTENANCE ADDITIVES: JET ENGINE SHOP

Activity	Weekly Manhours	Activity	Weekly Manhours
Alameda	19.38	Whiting Field	17.60
Brunswick	.06	Atlanta	16.52
Cecil Field	97.46	Dallas	6.48
Chase Field	108.92	Detroit	17.90
China Lake	--	Glenview	16.69
Corpus Christi	--	New Orleans	55.71
Iwakuni	.04	South Weymouth	24.02
Jacksonville	25.65	Willow Grove	3.56
Key West	58.38	CV	167.75
Kingsville	76.98	LPH	15.92
Lakehurst	31.94	Adak	21.21
Lemoore	94.06	Agana	178.65
Meridian	9.85	Atsugi	--
Miramar	262.58	Barbers Point	1.42
Moffett Field	2.65	Bermuda	15.93
Norfolk	96.81	Guantanamo Bay	60.31
North Island	94.90	Keflavik	69.87
Oceana	50.33	Lajes	2.25
Patuxent River	321.50	Mildenhall	--
Memphis	--	Misawa	7.65
Pensacola	131.15	Naha	49.35
Point Mugu	106.46	Roosevelt Roads	65.63
Warminster	--	Rota	62.90
Washington, D.C.	26.52	Sigonella	65.04
Whidbey Island	307.19	Cubi Point	374.75

SOURCE: *Work Center Staffing Standards: Aircraft Maintenance--Perform Intermediate Aircraft Maintenance--ACM-02*, NAVMMACLANT, January 13, 1978.

foundation of NAVMAN. The next section provides an overview of the model operation, along with the key features, inputs, and outputs. A detailed description of the model can be found in Appendix A of Volume II.

III. MODEL OVERVIEW

This section is intended to introduce the user to the NAVMAN model. It describes the key features, assumptions, inputs, outputs, and general logic of the computer program. Additional information for the analyst or programmer who is interested in the detailed logic of the model and the factors and variables contained in the computer program is given in Volume II.

KEY FEATURES

The NAVMAN model contains several key features, among which are:

- NAVMAN is to be used to estimate below-depot level aircraft maintenance personnel requirements on-board ship and at NASs.
- The statistical estimating relationships in the model reflect the current Navy requirements determination procedures for organizational and intermediate maintenance.
- The capability to perform manning sensitivity analyses is designed into the model to enable the user to determine the effect of alternative squadron sizes, R&M inputs, and flying-hour policies.
- The capability exists to override, for a number of variables, the values stored in the model.
- The level and detail of input data are variable. If, for example, the user cannot define data on a work center or work unit code (WUC) level, the model will spread an aggregate input, say, total maintenance manhours per sortie, to generate individual work-center personnel requirements. Further, NAVMAN will accept a variety of input variables including maintenance manhours per flying hour and per sortie, mean time between failure/mean time to repair (MTBF/MTTR), and any combination of the factors.

MODEL ASSUMPTIONS

The user should be aware of several assumptions and limitations of NAVMAN; listed below are the more important of these.

- Certain work centers are "directed" or "position" manned--that is, a certain number of personnel, independent of any reliability or flying program values, are required. The directed manning values in the SQMD calculations specify one person for work centers 010, 030, 060, 100, 200, and 300 and eight persons for work center 040. These requirements are based on aircraft squadron sizes ranging from 4 to 14. Because NAVMAN is designed to consider and evaluate larger squadron sizes, assumptions were necessary to determine extrapolated values beyond historical squadron sizes.
- If the workload data cannot be entered by PM and CM categories, the model will accept a TM input. The model, using percentages based on current Navy aircraft experiences, will divide the TM hours into scheduled and unscheduled maintenance workloads.
- In the case of R&M inputs submitted by WUC or TM, the workload is accumulated and then spread to the appropriate work centers based on historical percentages contained in the Navy SQMD. Because of the level of maintenance detail likely to be available during the conceptual design phase, the model has been designed to accept WUC inputs at the two-digit level only.
- Characteristic of any model based on historical maintenance data, there is an implicit assumption that technology, organization, and maintenance policy will remain unchanged in the future. The statistical standards, squadron organization, directed manning levels, and general aircraft characteristics should be periodically reviewed and updated to reflect changes.
- The Navy has recently developed a new method for determining the personnel requirements for intermediate-level maintenance. These methods, integral to NAVMAN, are presented in ACM-02. For permanently staffed work centers, requirements are directed manned or based either on the number and type of aircraft

supported or the number of subordinate work centers. For production work centers, the model bases requirements on the ACM-02 variable of maintenance manhours per aircraft. NAVMAN incorporates these functions even though the methods ignore the relationship between maintenance requirements and flying hours.

MODEL OPERATIONS

NAVMAN calculates maintenance personnel requirements for organizational- and intermediate-level maintenance. The general steps used in these separate calculations are described below.

Organizational Maintenance Calculations

Personnel requirements for organizational-level maintenance are determined on a work-center basis. Personnel for the work centers are related to either the direct servicing and maintenance of the aircraft and its subsystems or the administrative responsibilities such as supervision, material control, and data analysis. This work-center dichotomy is listed in Table 5 for all the organizational-level work centers.

Table 5

ORGANIZATIONAL-LEVEL WORK CENTERS

R&M Work Centers		Other Work Centers	
110	Power Plants	010	Maint. Officer
120	Airframe	020	Maint./Material Control
121	Corrosion Control	030	Maint. Administration
130	Aviator Equipment	040	Quality Assurance
131	Safety Equipment	050	Material Control
210	Electronics	060	Data Analysis
211,212	Elec. Fire Control	100	Aircraft Division
220	Elec./Instruments	140	Planned Maintenance
230	Weapons	200	Avionics/Arm. Div.
310	Plane Captains	300	Line Division
		320	Troubleshooters

The administrative (other) work centers are either "position" or "directed" manned (i.e., a specific number of billets are required), or are manned on the basis of standards that statistically relate hours to non-R&M factors such as flying hours, equipment inventories, or sorties. These standard equations and directed manning values are from the SQMD model. As mentioned above, the directed manning values in the SQMD model specify one person for the appropriate work centers (010, 030, 060, 100, 200, and 300; 040 has a requirement for 8 people) based on current Navy squadron sizes of from 4 to 14 aircraft. Because NAVMAN should have the capability of considering larger size squadrons, assumptions were necessary to determine extrapolated values beyond these historical squadron sizes. Discussions with SQMD analysts suggested the values used in NAVMAN for the directed manned work centers.

Personnel requirements for R&M-based work centers are calculated by dividing the total direct and indirect hours by the appropriate availability. NAVMAN calculates requirements on a work-center basis and, therefore, the preferred set of factor inputs are CM and PM factors for each work center. However, during the early stages of system acquisition to which the model is oriented, R&M requirements are specified as design goals and, commonly, at very aggregate levels. The design goals are often based on the performance of current aircraft systems of a similar type (i.e., a fighter aircraft or a fire control radar) taking into consideration any expected R&M improvements due to advances in the state of the art and/or technological change.

R&M values used during these early stages are typically not available to the level of detail desired. Furthermore, values based on analogous weapon system experience are often met with skepticism and resistance. To provide the maximum user flexibility when faced with these problems, NAVMAN accepts a wide range of possible R&M values and allows the user to test the sensitivity of the resulting manpower to changes in the workload.

The R&M input options available to the NAVMAN user include the following:

- o The type of maintenance workload. Data can be entered as PM, CM, or a combination of the two (TM). If the detail is available, separate values should be entered for both CM and PM. If the distinction cannot be made, TM data are entered. The model, using percentages based on current Navy aircraft, will break the TM hours into scheduled and unscheduled workloads.

- Work center or WUC data. The user can input R&M data on a work center or a 2-digit WUC basis. Analyses showed that a clean crossover from WUCs to work centers does not exist. Many of the WUCs at the 2-digit level indicate a workload for multiple work centers. Because of this problem, the model accumulates all workload reported in terms of WUCs and spreads the total workload to work centers on the basis of percentages developed from current Navy aircraft.
- Aggregate or disaggregate data. If the user cannot define the data on a work center or WUC basis, the model will spread an aggregate figure to the individual work centers. The user can enter a combination of disaggregate and aggregate data. For example, if values are known for certain shops because of the use of existing equipment, the user can enter that disaggregate data and then an aggregate figure for the remaining work centers. The model recognizes the disaggregate workload and adjusts the percentage spreads to allocate the aggregate workload to the remaining work centers.
- The form of the input variables. The model will accept, for CM and TM data, maintenance manhours per flying hour, maintenance manhours per sortie, and mean time between failure/mean time to repair values, or any combination of the factors. For PM, the model requires maintenance manhours per flying hour, per sortie, per flying day, and per week. If MTBF/MTTR data are used, more than one set of values for a work center can be entered. This would be appropriate for work centers with multiple equipment responsibilities.
- Data that do or do not include indirect factors. As mentioned in Section II, the direct maintenance workload must be augmented by indirect factors to account for PD, PA, and MR/PA. It is

assumed that all PM inputs do not include the indirect hours and therefore must be adjusted to include the indirect workload. CM data will include PA and MR/PA time if the data are taken from the 3M system. However, if contractor data or estimates are used, these indirect hours may not be included in the CM workload. The user can specify if the indirect hours are or are not included and the model will make the proper adjustments. It is assumed that TM data do not include indirect hours.

The following steps are used to determine personnel requirements for organizational-level maintenance:

1. Read organizational data and determine weekly flying program values.
2. Read any optional override values specified by the user.
3. Read R&M input data.
4. Compute raw PM and raw CM workload for each work center.
5. Add indirect factors to raw workloads to get total PM and CM workloads for each work center.
6. Calculate total AS workload and spread to the individual work centers.
7. Calculate FM workload for each work center.
8. Add any UT hours to sea workloads.
9. Calculate troubleshooter workload for shore squadrons and sea squadrons that are not fighter, attack, or antisubmarine. Allocate this workload to the appropriate work centers.
10. Convert total hourly workloads for each work center to fractional personnel requirements by dividing by appropriate availability.
11. Ensure that the minimum number of required personnel are assigned to the weapons work center (WC 230).
12. Convert fractional men to integer requirements using roundoff matrices. Set plus and minus hour bounds on the workloads.

13. Ensure the minimum of 2 plane captains per aircraft for the sea environment.
14. Set personnel and paygrade requirements for directed or standard manned work centers.
15. Set paygrade requirements for R&M work centers.
16. Determine total personnel and paygrade requirements for organizational-level maintenance.
17. Print output reports.
18. Perform any sensitivity analysis specified by the user.

Intermediate Maintenance: TAD Calculations

NAVMAN uses intermediate-level maintenance manhours per week (an input) and the number of aircraft per squadron to calculate a squadron's total AM workload. This total is spread to the five production divisions* (4XX Power Plants, 5XX Airframes, 6XX Avionics, 7XX Armament, and 8XX Aviators Equipment) based on historical factors stored in the model. SM hours, based on a factor per aircraft, are added to yield a subtotal for each division. This subtotal is divided by the appropriate availability to yield a personnel figure. AS hours are then calculated on the basis of this personnel number and added to AM and SM hours to yield total hours for a division. Dividing by the availability and converting to integer requirements gives the TAD requirements for each division.

The steps for determining intermediate-level TAD personnel requirements are:

1. Read the intermediate maintenance manhours per aircraft per week and the minimum number of avionics skills required.
2. Calculate total direct weekly intermediate AM for a squadron.
3. Spread the total direct hours to the appropriate production divisions using stored values or user inputs.
4. Multiply SM hours per aircraft by the number of aircraft for each production division and add to direct hours.

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*The Armament Division is not manned for certain types of aircraft.

5. Divide by the appropriate manhour availability to calculate an intermediate personnel figure.
6. Calculate AS hours for each production division based on the intermediate personnel figure.
7. Add AS hours to SM and AM hours to find total workloads for each production division.
8. Divide by the appropriate availability and round to an integer number to determine personnel requirements.
9. Compare the billets calculated for the avionics division to the minimum number of avionics skills required to ensure sufficient skill coverage.

Intermediate Maintenance: Permanent Cadre Calculations

NAVMAN estimates changes in the permanent portion of the AIMD at the NASs at which the aircraft are based and on the aircraft carriers. These changes in cadre personnel are based on the ACM-02 standard equations and directed values that use number of aircraft as the predicting variables. The remaining permanent positions manned by ACM-02 are independent of any changes caused by the addition of the aircraft. The work centers considered are:

Work Center Number	Work Center Name
021	Production Control Office
050	Material Control
060	Data Analysis
6XX	Precision Measurement Equipment
9XX	GSE Production Control
9XX	GSE Materiel Control
9XX	GSE Production Work Centers

NAVMAN uses the ACM-02 equations to calculate the permanent cadre (in the above work centers) before the aircraft are added to the NASs and the carrier and after the aircraft are added. The difference is reported as the additional cadre personnel required.

MODEL INPUTS

There are three types of necessary inputs to the model--organizational, reliability and maintainability, and intermediate level. The organizational inputs describe the fleet and squadron characteristics, flying-hour programs, and maintenance policies:

Organizational Inputs:

- o Sortie rate at NASs (sorties per aircraft per flying day).
- o Sortie rate on-board ship.
- o Sortie length at NASs (hours per sortie).
- o Sortie length on-board ship.
- o Flying days per week at NASs.
- o Flying days per week on-board ship.
- o Number of aircraft per squadron.
- o Number of squadrons.
- o Aircraft type.
- o Number of work shifts.

The form of the R&M inputs is optional depending on the level of detail the user desires or can reasonably supply:

R&M Inputs:

- o Type of workload (scheduled, unscheduled, or total).
- o Appropriate WUC or work-center number.
- o Maintenance manhours per sortie or per flying hour or MTBF/MTTR (for unscheduled or total maintenance).
- o Scheduled hours per week, per flying day, per sortie, and per flying hour.

The sortie rate, sortie length, and number of flying days define the flying-hour programs and are used in conjunction with the R&M inputs to estimate the total organizational workload for each shop.

The intermediate-level (I-level) inputs include basing and I-level repair data.

Intermediate-Level Inputs:

- o Intermediate-level maintenance manhours per aircraft per week.
- o Number of skills required in the avionics division.
- o The total number of aircraft on-board a carrier.
- o The number of squadrons of the aircraft that would be assigned to a carrier.
- o The number of NASs where the aircraft will be shore-based.
- o The number of squadrons of the new aircraft stationed at each shore base.
- o The number of aircraft stationed at the shore bases before the aircraft being considered are assigned.

These intermediate-level inputs are used to determine the TAD I-level personnel assigned to the operational squadrons and the change in AIMD permanent personnel on carriers and at the NASs.

In addition to the required inputs, there are two sets of optional inputs--sensitivity and override values. The sensitivity inputs are used to recalculate personnel requirements and include:

- o New number of aircraft per squadron.
- o New sortie rates.
- o New number of flying days per week.
- o An increase or reduction in maintenance hours.

Values stored in the model that can be overridden by the user include:

- o A work center's total maintenance to scheduled/unscheduled maintenance factors.
- o The aggregate maintenance or WUC hours to individual work-centers factors for total, scheduled, and unscheduled work-loads.
- o The spread of total I-level workload to the five production divisions.
- o The I-level support equipment manhours per aircraft.

- o The GSE factors.
- o The minimum number of weapons loaders required.

A thorough description of the input requirements is given in Section IV.

MODEL FACTORS

Current Navy methods for determining organizational and intermediate personnel requirements include a number of factors based on analysis or audit of current aircraft operations. These factors are stored in the model and are used to determine indirect hours, personnel availabilities, round-offs, and paygrades. As presented in Volume II, these factors include:

- o Fractional man round-off tables.
- o Paygrade matrices.
- o AS factors by environment and work center.
- o FM factors by work center.
- o MR/PA factors.
- o PA factors.
- o PD factors by environment and work center.
- o Standard equation factors (organizational and intermediate).
- o Availability by environment.
- o UT hours for aircraft at sea.

MODEL OUTPUTS

Model outputs are at various levels of detail. Ship requirements and shore requirements, for the total fleet, are included for individual squadrons and by work center. The following output is generated by NAVMAN:

- o Summary of inputs--type of aircraft, fleet size, squadron size, flying-hour program ship and shore, and R&M information.
- o Total fleet personnel requirements--for sea and shore, by paygrade.

- o Squadron personnel requirements and workloads by work center--sea and shore.
- o The individual components of the total workload for each work center and the "leverage" in the workload for each work center.
- o Sensitivity analysis--on R&M inputs, flying hours, or squadron size (optional).

The model outputs are described further in Section IV.

SENSITIVITY ANALYSIS

As mentioned, NAVMAN allows the user to determine the effect on personnel requirements of changing the value of certain input variables. The user may request as many sensitivity runs as he wants, but care must be taken that the sensitivity inputs accomplish the desired results. Sensitivity values replace base-case values in the model, and succeeding sensitivity analyses may use previous sensitivity inputs rather than the original base-case inputs. Knowledge of the steps taken by the model during sensitivity analysis is necessary to understand the potential implications of multiple sensitivity analyses. As a check, the model always presents the squadron sizes and flying program values used in the calculations in the output report. However, the model does not reflect any changes to the R&M inputs.

If the user changes the number of aircraft per squadron, that variable is changed in the model along with the total fleet size. The number of squadrons is assumed not to change.) The weekly sorties and flying hours are changed to reflect the new squadron size, and the raw work-center workloads (before the indirect factors for MR/PA, PA, and PD are added) are changed to reflect these new flying programs. The model then branches to Step 5 in the organizational maintenance calculations.

If the sortie rate or flying days are changed, the model calculates new flying program values and branches to Step 3 to calculate new workloads based on these new values.

If the maintenance hours are affected, new raw workloads are calculated and the model branches to Step 5 to calculate new personnel requirements. If a sensitivity run is made before a run changing the maintenance workloads by a prescribed factor, the factor will be applied to the workloads calculated in the earlier sensitivity run rather than the original workloads.

When used properly to achieve the desired results, the sensitivity option in NAVMAN can be a valuable tool for determining the effects on personnel of a range of values for a variable that may not be well defined during system development.

IV. RUNNING THE MODEL: INPUT REQUIREMENTS AND OUTPUT REPORTS

This section presents the information necessary to use the NAVMAN model. Included are a description of the input requirements, the output reports, and a sample run of the model.

INPUT REQUIREMENTS

NAVMAN will accept input from computer cards, tape, or disc data sets depending on the input medium defined in the job control cards. The logical record length used is 80 characters--the length of a standard computer card. Therefore, although most records require only a few columns or characters for the input data, each record must be 80 characters long. The numerical data should be entered with the appropriate decimal points or right-justified in the proper fields of the records.

There are five sets of input data; in the order required, they are:

1. Organizational and flying hour
2. Override values (optional)
3. Reliability and maintainability
4. Intermediate maintenance
5. Sensitivity analyses (optional)

Each of these input sets is described below.

Organizational and Flying-Hour Inputs (Record Numbers 1 through 12)

The organizational and flying-hour inputs are required by NAVMAN and are used to determine fleet size and flying programs for sea and shore. The appropriate formats and required variables are shown in Table 6. The sortie rate and sortie length variables are sorties per aircraft per flying day and hours per sortie, respectively. NAVMAN will estimate personnel requirements for ten different types of fixed-wing aircraft and helicopters. The various types of aircraft are listed in Volume II, Table D.1.

Table 6

ORGANIZATIONAL AND FLYING-HOUR INPUTS

Record No.	Columns	Format	Variable
1	1-80	C80	Title[a]
2	1-15	C15	Type of aircraft[b]
3	1-4	F4	Number of aircraft per squadron
4	1-4	F4	Number of squadrons
5	1-4	F4	Sortie rate at sea
6	1-4	F4	Sortie rate on shore
7	1-4	F4	Sortie length at sea
8	1-4	F4	Sortie length on shore
9	1-4	F4	Number of flying days per week at sea
10	1-4	F4	Number of flying days per week on shore
11	1-4	F4	Number of work shifts
12	1-4	F4	Number of override inputs

[a]The title is printed as a heading on every output report.
[b]The type of aircraft must begin in Column 1.

Override Values (Numbers 13 through 15)

The user has the option of overriding a number of factors stored in the model* if he has information or knowledge that other values may be more appropriate for the aircraft being considered. The number of variables to be replaced is indicated by the number of the override inputs record (record 12) of the organizational and flying-hour inputs. Each default input is either 2 or 3 records long, depending on the variable of interest. The first record specifies the default code (and therefore the variable of interest) and the next one or two records contain the values for the variable. The variables and required formats are shown in Table 7 for the various default codes. The input records for default overrides are

Record No.	Columns	Format	Variable
13	1	C1	The default variable code
14 15	} see Table 7		

*These model factors are listed in Volume II, Appendix D.

Table 7

OVERRIDE VARIABLES AND INPUT FORMATS

Default Code	Model Variables To Be Replaced		Format
1	The percentage spreads (23) of TM workloads to CM and PM workloads for each work center	Record 13: Record 14:	12 F4 11 F4
2	The percentage spreads (23) of an aggregate TM workload to the individual work centers	Record 13: Record 14:	12 F4 11 F4
3	The percentage spreads (23) of an aggregate PM workload to the individual work centers	Record 13: Record 14:	12 F4 11 F4
4	The percentage spreads (23) of an aggregate CM workload to the individual work centers	Record 13: Record 14:	12 F4 11 F4
5	The percentage spreads (5) of total I-level workload to the 5 production divisions	Record 13: Record 14:	5 F4 Not required
6	The weekly I-level support equipment maintenance manhours per aircraft for each division for sea (5) and shore (5)	Record 13:	5 F4, 5 F4 Not required
7	The weekly I-level GSE workloads per aircraft for sea (1) and shore (1)	Record 13: Record 14:	F4, F4 Not required
8	The minimum number (1) of weapons loaders per aircraft for work center 230	Record 13: Record 14:	F4 Not required
9	The work center code (1) and any additional hours (1) to be added to the work center	Record 13: Record 14:	C3, F4 Not required

NOTE: The number in parentheses in the variable descriptions indicates the number of input values required.

There should be as many sets of record numbers 13 through 15 as indicated by record number 12. The last code (default code = 9) allows the user to preset a number of hours into a work center. This may be appropriate if there is a workload not covered by the model or the inputs.

Reliability and Maintainability (Record Numbers 16 through 17)

The R&M inputs are used to calculate the organizational-level aircraft maintenance workloads. The number of R&M records is a function of the amount of data available to the user; the minimum number is two--one aggregate (XXX code = 999) workload record and the end of R&M input record (XXX code = 888). The format of the R&M inputs is shown in Table 8.

Table 8

R&M INPUTS AND VARIABLE DEFINITIONS

Record No.	Columns	Format	Variable (Computer Name)
16	1-2	C2	Type of maintenance data (AA_TYPE)
	4	C1	Flag for indirect hours (I_TYPE)
	6	C1	Flag for form of R&M data (J_TYPE)
	8	C1	Flag for WUC or WC data (K_TYPE)
	10-12	C3	WC or WUC indicator (XXX_CODE)
	16-19	F4	R&M data (V1)
	22-25	F4	R&M data (V2)
	28-31	F4	R&M data (V3)
	34-37	F4	R&M data (V4)
17	10-12	C3	'888' indicates end of R&M input

NOTES:

AA_TYPE either PM, CM, or TM depending on the type of maintenance data

I_TYPE equal to 1 if AA_TYPE = CM and the data do not include any indirect hours; equal to 0 otherwise

J_TYPE for CM and TM data
= 1 if using MMH/FH
= 2 if using MMH/S
= 3 if using MTBF/MTTR
for PM data, this field is ignored by the model

K_TYPE = 0 if work-center data
= 1 if WUC data

XXX-CODE the three-digit work-center number or two-digit WUC
= 999 if aggregate data

V1: for PM data = MMH/WEEK
for CM or TM data = MTBF or MMH/FH or MMH/S

V2: for PM data = MMH/FLYING DAY
for CM or TM data = MTTR

V3: for PM data = MMH/FH; for CM or TM data, this field is ignored by the model

V4: for PM data = MMH/S; for CM or TM data, this field is ignored by the model.

Intermediate Maintenance (Record Numbers 18 through 20)

The intermediate maintenance inputs are used to calculate the personnel requirements for the permanent and temporary portions of the AIMD. The necessary records are listed in Table 9. Record type 18 is used to determine the TAD requirements per squadron, and record types 19 and 20 are used to determine the number of aircraft being added to aircraft carriers and NASs in order to determine the effect on the

Table 9

INTERMEDIATE MAINTENANCE INPUTS

Record No.	Columns	Format	Variable
18	4-7	F4	I-level maintenance manhours per week per aircraft
	10-13	F4	Minimum number of avionics skills required
19	4-7	F4	Number of squadrons of these aircraft on a carrier
	10-13	F4	Total number of aircraft on a carrier
	16-19	F4	Total number of NASs where the aircraft will be shore-based
20	4-7	F4	Number of aircraft at the NAS before the new aircraft are added
	10-13	F4	The number of squadrons of the new aircraft added to the NAS

permanent cadre of the AIMD. The number of record number 20 is equal to the number of NASs in record 19.

Sensitivity Analyses (Record Number 21)

The user of NAVMAN has the option of performing sensitivity analyses on the model outputs. The format of a sensitivity record (record 21) is:

Columns	Format	Variable
1	C1	Sensitivity code
2-5	F4	Sensitivity value 1
6-9	F4	Sensitivity value 2

The sensitivity codes and the appropriate values are listed in Table 10. There may be as many sensitivity runs as the user desires.

Table 10

SENSITIVITY CODES AND INPUT REQUIREMENTS

Sensitivity Code	Variable Affected	Sensitivity Value 1	Sensitivity Value 2
1	Aircraft per squadron	New number of aircraft	Not used
2	Sortie rate at sea and sortie rate on shore	New sortie rate at sea	New sortie rate on shore
3	Flying days per week at sea and flying days per week on shore	New number of flying days at sea	New number of flying days on shore
4	R&M inputs	If changing | Value = PM | 1 CM | 2 TM | 3	Factor applied to original workload

The end of the input is designated with a record (record number 22) containing a Z in column 1.

In summary, NAVMAN requires as input record numbers 1 through 12, 16 through 20, and 22. The other records are optional.

A sample input is shown in Table 11. The example is for a fighter aircraft with 10 aircraft in a squadron. Override values are given for the percentage spreads of TM hours to the various production work centers. Separate R&M data are used for five of the work centers (110, 130, 131, 210, 230), and a total figure of 10 maintenance manhours per flying hour (the 999 card) is to be spread to the remaining 5 production work centers. The model recognizes that separate inputs are given for some of the work centers and will adjust the percentages to spread the remaining aggregate workload; in this example, the 10 hours will be spread evenly to the remaining work centers. Finally, sensitivity runs on the sortie rates are needed.

Table 11

SAMPLE NAVMAN INPUT

Record No.	
1	THIS IS AN EXAMPLE RUN OF THF NAVMAN MODEL
2	FIGHTER
3	10 AIRCRAFT PER SQUADRON
4	20 NUMBER OF SQUADRONS
5	2.0 SORTIE RATE SEA
6	1.0 SORTIE RATE SHORE
7	1.5 SORTIE LENGTH SEA
8	1.0 SORTIE LENGTH SHORE
9	5.0 FLYING DAYS WEEK SEA
10	4.0 FLYING DAYS WLEK SHORE
11	2 NUMBER OF SHIFTS
12	1 NUMBER OF DEFAULT INPUTS
13	2 OVERRIDE TM SPREADS TO WORK CENTERS
14	0 0 0 0 0 0 0 .1 .1 .1 .1 .1
15	0 0 .1 .1 .1 .1 0 0 .1 0 0
16	TM 1 1 0 110 2 R&M data
16	TM 1 1 0 130 .5 R&M data
16	TM 1 1 0 131 .5 R&M data
16	TM 1 1 0 210 2 R&M data
16	TM 1 1 0 230 1 R&M data
16	TM 1 1 0 999 10 R&M data
17	888 End of R&M data
18	75 10 I-level MMH/WEEK/AC, Avionics skills
19	2 90 2 I-level basing data
20	150 10 Data for NAS 1
20	200 12 Data for NAS 2
21	2 1.0 .75 Sensitivity for sortie rates
22	Z End of input

OUTPUT EFFORTS

The basic NAVMAN output consists of five reports--the first two are restatements of the user inputs and the last three present the manhour and personnel outputs of the model. These five reports are printed for the basic set of model inputs and for any sensitivity cases desired by the user. Each report is described below and sample output, based on the input data in Table 11, is given as an example.

Report 1: Fleet Description and Operational Assumptions

The first output report presents a recapitulation of the organizational inputs. The type and number of aircraft and the flying programs are shown for sea and shore. Also presented are any override values specified by the user. This summary permits the user to review his data as well as document the input values that were used to generate the personnel requirements.

Report 2: Reliability and Maintainability Values

The second output report presents a comprehensive review of the R&M and the intermediate-level maintenance inputs to the model. The work-center matrix lists the values for each type of workload data for PM and CM or for TM. Any user inputs replace zero values in this matrix. If WUC data are entered, an additional matrix is printed listing the type of input (MMH/FH, MMH/S, or MTBF/MTTR) and value for each WUC.

The second part of Report 2 shows the work-center spreads applied to any aggregate data (999 row of work-center matrix) and to any WUC data. The values stored in the model are printed unless the user has specified override values for any or all of the percentage spreads.

The last part of Report 2 presents the intermediate maintenance inputs used to generate the temporary and permanent portions of the AIMD.

Report 3: Total Fleet Maintenance Personnel Requirements

The third report presents the total fleet personnel requirements and appropriate paygrade levels for both the sea and the shore environments. The paygrade matrix represents organizational maintenance requirements for enlisted personnel. The only officers in the organizational squadron (excluding pilots) are in work centers 010, the Maintenance Office, and are not shown in the paygrade matrix. The TAD personnel attached to the squadron are shown at the bottom of the paygrade matrix along with any changes in the permanent portion of the AIMD.* The total personnel figures shown in the first two lines of Report 3 are equal to the total of the paygrade matrix plus the total AIMD TAD plus the total personnel in work center 010.

Report 4: Detailed Squadron Maintenance Personnel Requirements

The fourth report presents the manhour and personnel requirements by work center for the organizational and intermediate maintenance requirements of an operational squadron. Sea and shore requirements as well as subtotals by organizational division (aircraft, avionics/armament, line, and overhead) are presented. A manhour value of 0 for a work center where personnel are required indicates a directed (position) manning requirement.

Report 5: Work-Center Hour Breakdowns

The fifth and last NAVMAN report shows the breakdown of the organizational-level workload by work center and the personnel sensitivities to these work-center workloads. The total workload is broken into the PM, CM, AS, and Other hours (FM, UT, and any user override inputs) components in the first part of Report 5. The last part presents the number of manhours that can be added to or subtracted from a work center's workload without affecting the personnel requirement. For example, if a work center shows a minus figure of 12 hours and a plus figure of 51 hours, the workload for that work center can be decreased by 12 hours or increased by 51 hours and the personnel requirement will remain the same. These statistics can be helpful when evaluating the personnel effects of any R&M improvements. A minus figure of 0 often appears for work centers that are constrained by a minimum manning requirement.

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*The permanent figures could be added to the total personnel requirements if the number of carriers were known.

For example, the armament or plane captain work centers may require a minimum number of people regardless of the workload and reducing the workload will not affect this minimum requirement.

SAMPLE RUN OF THE MODEL

A sample of the NAVMAN report printouts are presented below.

REPORT 1--BASIC MODEL INPUTS

THIS IS AN EXAMPLE RUN OF THE NAVMAN MODEL

I. FLEET DESCRIPTION AND OPERATIONAL ASSUMPTIONS

A. AIRCRAFT TYPE	FIGHTER	
B. AIRCRAFT PER SQUADRON	10	
C. NUMBER OF SQUADRONS	20	
D. TOTAL FLEET SIZE	200	
	SEA	SHORE
E. SORTIE RATE(SORTIES/AC/FLYING DAY)	2.00	1.00
F. MEAN SORTIE LENGTH (HOURS)	1.50	1.00
G. FLYING DAYS PER WEEK	5.0	4.0
H. TOTAL FLYING HOURS/SQUADRON/WEEK	150.00	40.00
I. TOTAL FLYING HOURS/AIRCRAFT/WEEK	15.00	4.00

OVERRIDE INPUTS

CODE	VALUES											
2	0	0	0	0	0	0	0	.1	.1	.1	.1	.1
2	0	0	.1	.1	.1	.1	0	0	.1	0	0	

REPORT 2--BASIC MODEL INPUTS

THIS IS AN EXAMPLE RUN OF THE NAVMAN MODEL

II. RELIABILITY AND MAINTAINABILITY VALUES

A. INPUTS

WORK CENTER	PM				CM/TM			
	MMH/W	MMH/D	MMH/FH	MMH/S	MMH/FH	MMH/S	MTBF	MTTR
110 POWER PLANTS BRANCH	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00
120 AIRFRAMES BRANCH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
121 CORROSION CONTROL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
130 AVIATOR EQUIPMENT	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00
131 SAFETY EQUIPMENT	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00
210 ELECTRICAL BRANCH	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00
211 ELECTRONIC FIRE CONTROL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
220 ELECTRICAL/INSTRUMENTS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
230 WEAPONS BRANCH	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
240 PHOTO SHOP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
310 PLANE CAPTAINS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
999 AGGREGATE	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00

B. PM AND CM SPREAD BY WORK CENTER (%)

	110	120	121	130	131	140	210	211	220	230	310	320
TM - VF,VA	.100	.100	.100	.100	.100	.000	.100	.100	.100	.100	.100	.000
PM - VF,VA	.096	.235	.000	.003	.065	.000	.034	.030	.044	.162	.331	.000
CM - VF,VA	.095	.173	.063	.011	.053	.000	.079	.090	.124	.110	.202	.000

C. AIMD INPUTS

MMH PER AC PER WEEK	75
NUMBER OF SQUADRONS ON A CARRIER	2
TOTAL NUMBER ALL AIRCRAFT ON A CARRIER	90
NUMBER OF NAS DEPLOYED	2

AIR STATION	NO. OF AC	NO. SQ. ADDED
1	150	10
2	200	12

NUMBER OF AVIONICS SKILLS 10

REPORT 3--BASIC MODEL INPUTS

THIS IS AN EXAMPLE RUN OF THE NAVMAN MODEL

III. TOTAL FLEET MAINTENANCE MANPOWER REQUIREMENTS

TOTAL PERSONNEL WHEN CARRIER DEPLOYED IS 3360.0

TOTAL PERSONNEL WHEN AT NAVAL AIRSTATION IS 2500.0

BY PAYGRADE:

	SEA		SHORE	
	PER SQUADRON	TOTAL FLEET	PER SQUADRON	TOTAL FLEET
E-9	1.00	20.00	1.00	20.00
E-8	5.00	100.00	3.00	60.00
E-7	8.00	160.00	4.00	80.00
E-6	21.00	420.00	19.00	380.00
E-5	29.00	580.00	14.00	280.00
E-4	33.00	660.00	20.00	400.00
E-3	52.00	1040.00	35.00	700.00
E-2	0.00	0.00	0.00	0.00
* TOTAL	149.00	2980.00	96.00	1920.00
AIMD TAD	18.00	360.00	28.00	560.00

ADDED AIMD CADRE PERSONNEL

PER CARRIER	2.00
NAS- 1	12.00
NAS- 2	17.00

* DOES NOT INCLUDE PERSONNEL IN MAINTENANCE OFFICE (WC010) WHICH ARE LT. CMDRS

REPORT 4--BASIC MODEL INPUTS

THIS IS AN EXAMPLE RUN OF THE NAVMAN MODEL

IV. DETAILED SQUADRON MAINTENANCE MANPOWER REQUIREMENTS

WORK CENTER		SEA MANHOURS	SEA MANPOWER	SHORE MANHOURS	SHORE MANPOWER
010	MAINTENANCE OFFICER	0.00	1.00	0.00	1.00
020	MAINTENANCE/MATERIAL CONTROL	201.16	7.00	148.05	8.00
030	MAINTENANCE ADMINISTRATION	0.00	1.00	0.00	1.00
040	QUALITY ASSURANCE	0.00	8.00	0.00	8.00
050	MATERIAL CONTROL	187.55	3.00	92.35	3.00
060	DATA ANALYSIS	0.00	1.00	0.00	1.00
SUB TOTAL	OVERHEAD	388.71	21.00	240.41	22.00
100	AIRCRAFT DIVISION	0.00	1.00	0.00	1.00
110	POWER PLANTS BRANCH	799.45	13.00	213.87	7.00
120	AIRFRAMES BRANCH	766.13	12.00	233.54	7.00
121	CORROSION CONTROL	585.54	9.00	169.05	5.00
130	AVIATOR EQUIPMENT	214.38	4.00	66.55	2.00
131	SAFETY EQUIPMENT	277.18	5.00	91.36	3.00
140	PLANNED MAINTENANCE	77.59	2.00	31.75	1.00
SUB TOTAL	AIRCRAFT DIVISION	2720.28	46.00	806.12	26.00
200	AVIONICS/ARMAMENT DIVISION	0.00	1.00	0.00	1.00
210	ELECTRICAL BRANCH	808.56	13.00	223.05	7.00
211	ELECTRONIC FIRE CONTROL	875.30	14.00	240.31	8.00
220	ELECTRICAL/INSTRUMENTS	828.83	13.00	228.08	7.00
230	WEAPONS BRANCH	468.10	16.00	121.46	16.00
240	PHOTO SHOP	0.00	0.00	0.00	0.00
SUB TOTAL	AVIONICS/ARMAMENT DIVISIO	2980.79	57.00	812.89	39.00
300	LINE DIVISION	0.00	1.00	0.00	1.00
310	PLANE CAPTAINS	1008.48	20.00	281.62	9.00
320	TROUBLE SHOOTERS	0.00	5.00	0.00	0.00
SUB TOTAL	LINE DIVISION	1008.48	26.00	281.62	10.00
ORGANIZATIONAL MAINTENANCE TOTAL		7098.25	150.00	2141.04	97.00
AIMD TAD REQUIREMENTS					
POWER PLANTS			4.00		6.00
AIRFRAMES			2.00		4.00
AVIONICS			10.00		14.00
ARMAMENT			1.00		2.00
AVIATOR EQUIPMEN			1.00		2.00

REPORT 5--BASIC MODEL INPUTS

THIS IS AN EXAMPLE RUN OF THE NAVMAN MODEL

V. WORK CENTER HOUR BREAKDOWNS

	SEA					SHORE				
WORK CENTER	CM	PM	AS	OTH	TOT	CM	PM	AS	OTH	TOT
010 MAINTENANCE OFFICER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
020 MAINTENANCE/MATERIAL CO	0.0	0.0	179.5	21.7	201.2	0.0	0.0	139.3	8.8	148.1
030 MAINTENANCE ADMINISTRAT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
040 QUALITY ASSURANCE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
050 MATERIAL CONTROL	0.0	0.0	166.3	21.3	187.6	0.0	0.0	86.7	5.7	92.4
060 DATA ANALYSIS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100 AIRCRAFT DIVISION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
110 POWER PLANTS BRANCH	386.1	198.9	157.9	56.6	799.5	87.1	46.0	64.6	16.2	213.9
120 AIRFRAMES BRANCH	329.4	212.9	165.8	58.0	766.1	84.2	54.8	67.8	26.8	233.5
121 CORROSION CONTROL	495.0	0.0	85.2	5.3	585.5	132.0	0.0	34.9	2.2	169.1
130 AVIATOR EQUIPMENT	99.2	19.5	80.5	15.2	214.4	26.5	5.2	32.9	1.9	66.6
131 SAFETY EQUIPMENT	74.2	50.7	132.6	19.6	277.2	19.8	13.5	54.3	3.8	91.4
140 PLANNED MAINTENANCE	0.0	0.0	71.0	6.6	77.6	0.0	0.0	29.1	2.7	31.8
200 AVIONICS/ARMAMENT DIVIS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
210 ELECTRICAL BRANCH	498.1	108.8	129.4	72.2	808.6	127.9	28.1	53.0	14.1	223.0
211 ELECTRONIC FIRE CONTROL	522.4	84.6	186.3	81.9	875.3	134.2	21.8	76.2	8.1	240.3
220 ELECTRICAL/INSTRUMENTS	504.2	102.8	170.5	51.4	828.8	119.5	24.8	69.8	14.0	228.1
230 WEAPONS BRANCH	187.2	105.3	123.1	52.5	468.1	42.2	24.3	50.4	4.5	121.5
240 PHOTO SHOP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300 LINE DIVISION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
310 PLANE CAPTAINS	297.0	245.7	274.7	191.1	1008.5	72.6	60.8	112.4	35.8	281.6
320 TROUBLE SHOOTERS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

MANPOWER SENSITIVITY TO WORKLOAD

	SEA			SHORE		
WORK CENTER	MINUS HOURS	REQ HOURS	PLUS HOURS	MINUS HOURS	REQ HOURS	PLUS HOURS
110 POWER PLANTS BRANC	12.0	799.5	51.0	7.5	213.9	25.4
120 AIRFRAMES BRANCH	41.6	766.1	21.4	27.2	233.5	5.7
121 CORROSION CONTROL	56.3	585.5	9.8	31.5	169.1	2.9
130 AVIATOR EQUIPMENT	15.9	214.4	50.2	32.2	66.6	2.2
131 SAFETY EQUIPMENT	12.6	277.2	53.6	22.6	91.4	11.8
210 ELECTRICAL BRANCH	21.1	808.6	41.9	16.7	223.0	16.2
211 ELECTRONIC FIRE CO	24.8	875.3	38.2	1.1	240.3	30.8
220 ELECTRICAL/INSTRUM	41.3	828.8	21.7	21.7	228.1	11.2
230 WEAPONS BRANCH	0.0	468.1	571.4	0.0	121.5	404.9
240 PHOTO SHOP	0.0	0.0	0.0	0.0	0.0	0.0
310 PLANE CAPTAINS	0.0	1008.5	251.5	10.5	281.6	21.4

REPORT 1--SENSITIVITY CASES

THIS IS AN EXAMPLE RUN OF THE NAVMAN MODEL

I. FLEET DESCRIPTION AND OPERATIONAL ASSUMPTIONS

A.	AIRCRAFT TYPE	FIGHTER	
B.	AIRCRAFT PER SQUADRON	10	
C.	NUMBER OF SQUADRONS	20	
D.	TOTAL FLEET SIZE	200	
		SEA	SHORE
E.	SORTIE RATE(SORTIES/AC/FLYING DAY)	1.00	0.75
F.	MEAN SORTIE LENGTH (HOURS)	1.50	1.00
G.	FLYING DAYS PER WEEK	5.0	4.0
H.	TOTAL FLYING HOURS/SQUADRON/WEEK	75.00	30.00
I.	TOTAL FLYING HOURS/AIRCRAFT/WEEK	7.50	3.00

REPORT 2--SENSITIVITY CASES

THIS IS AN EXAMPLE RUN OF THE NAVMAN MODEL

II. RELIABILITY AND MAINTAINABILITY VALUES

A. INPUTS

WORK CENTER	PM				CM/TM			
	MMH/W	MMH/D	MMH/FH	MMH/S	MMH/FH	MMH/S	MTBF	MTTR
110 POWER PLANTS BRANCH	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00
120 AIRFRAMES BRANCH	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
121 CORROSION CONTROL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
130 AVIATOR EQUIPMENT	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00
131 SAFETY EQUIPMENT	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00
210 ELECTRICAL BRANCH	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00
211 ELECTRONIC FIRE CONTROL	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
220 ELECTRICAL/INSTRUMENTS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
230 WEAPONS BRANCH	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00
240 PHOTO SHOP	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
310 PLANE CAPTAINS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
999 AGGREGATE	0.00	0.00	0.00	0.00	10.00	0.00	0.00	0.00

B. PM AND CM SPREAD BY WORK CENTER (%)

	110	120	121	130	131	140	210	211	220	230	310	320
TM - VF,VA	.100	.100	.100	.100	.100	.000	.100	.100	.100	.100	.100	.000
PM - VF,VA	.096	.235	.000	.003	.065	.000	.034	.030	.044	.162	.331	.000
CM - VF,VA	.095	.173	.063	.011	.053	.000	.079	.090	.124	.110	.202	.000

C. AIMD INPUTS

MMH PER AC PER WEEK	75
NUMBER OF SQUADRONS ON A CARRIER	2
TOTAL NUMBER ALL AIRCRAFT ON A CARRIER	90
NUMBER OF NAS DEPLOYED	2

AIR STATION	NO. OF AC	NO. SQ. ADDED
1	150	10
2	200	12

NUMBER OF AVIONICS SKILLS 10

REPORT 3--SENSITIVITY CASES

THIS IS AN EXAMPLE RUN OF THE NAVMAN MODEL

III. TOTAL FLEET MAINTENANCE MANPOWER REQUIREMENTS

TOTAL PERSONNEL WHEN CARRIER DEPLOYED IS 2560.0

TOTAL PERSONNEL WHEN AT NAVAL AIRSTATION IS 2300.0

BY PAYGRADE:

	SEA		SHORE	
	PER SQUADRON	TOTAL FLEET	PER SQUADRON	TOTAL FLEET
E-9	1.00	20.00	1.00	20.00
E-8	4.00	80.00	3.00	60.00
E-7	4.00	80.00	4.00	80.00
E-6	18.00	360.00	18.00	360.00
E-5	19.00	380.00	14.00	280.00
E-4	21.00	420.00	18.00	360.00
E-3	42.00	840.00	28.00	560.00
E-2	0.00	0.00	0.00	0.00
* TOTAL	109.00	2180.00	86.00	1720.00
AIMD TAD	18.00	360.00	28.00	560.00

ADDED AIMD CADRE PERSONNEL

PER CARRIER	2.00
NAS- 1	12.00
NAS- 2	17.00

* DOES NOT INCLUDE PERSONNEL IN MAINTENANCE OFFICE (WC010) WHICH ARE LT. CMDRS

REPORT 4--SENSITIVITY CASES

THIS IS AN EXAMPLE RUN OF THE NAVMAN MODEL

IV. DETAILED SQUADRON MAINTENANCE MANPOWER REQUIREMENTS

WORK CENTER		SEA MANHOURS	SEA MANPOWER	SHORE MANHOURS	SHORE MANPOWER
010	MAINTENANCE OFFICER	0.00	1.00	0.00	1.00
020	MAINTENANCE/MATERIAL CONTROL	172.04	6.00	144.17	8.00
030	MAINTENANCE ADMINISTRATION	0.00	1.00	0.00	1.00
040	QUALITY ASSURANCE	0.00	8.00	0.00	8.00
050	MATERIAL CONTROL	129.73	2.00	84.65	3.00
060	DATA ANALYSIS	0.00	1.00	0.00	1.00
SUB TOTAL	OVERHEAD	301.78	19.00	228.82	22.00
100	AIRCRAFT DIVISION	0.00	1.00	0.00	1.00
110	POWER PLANTS BRANCH	437.29	7.00	168.81	5.00
120	AIRFRAMES BRANCH	421.54	7.00	184.01	6.00
121	CORROSION CONTROL	301.57	5.00	131.19	4.00
130	AVIATOR EQUIPMENT	120.68	2.00	54.06	2.00
131	SAFETY EQUIPMENT	157.58	3.00	75.42	3.00
140	PLANNED MAINTENANCE	46.34	1.00	27.59	1.00
SUB TOTAL	AIRCRAFT DIVISION	1484.99	26.00	641.07	22.00
200	AVIONICS/ARMAMENT DIVISION	0.00	1.00	0.00	1.00
210	ELECTRICAL BRANCH	448.93	7.00	174.06	6.00
211	ELECTRONIC FIRE CONTROL	488.78	8.00	190.25	6.00
220	ELECTRICAL/INSTRUMENTS	452.70	7.00	179.82	6.00
230	WEAPONS BRANCH	267.84	16.00	97.61	16.00
240	PHOTO SHOP	0.00	0.00	0.00	0.00
SUB TOTAL	AVIONICS/ARMAMENT DIVISIO	1658.24	39.00	641.74	35.00
300	LINE DIVISION	0.00	1.00	0.00	1.00
310	PLANE CAPTAINS	591.29	20.00	228.81	7.00
320	TROUBLE SHOOTERS	0.00	5.00	0.00	0.00
SUB TOTAL	LINE DIVISION	591.29	26.00	228.81	8.00
ORGANIZATIONAL MAINTENANCE TOTAL		4036.29	110.00	1740.43	87.00
AIMD TAD REQUIREMENTS					
POWER PLANTS			4.00		6.00
AIRFRAMES			2.00		4.00
AVIONICS			10.00		14.00
ARMAMENT			1.00		2.00
AVIATOR EQUIPMEN			1.00		2.00

REPORT 5--SENSITIVITY CASES

THIS IS AN EXAMPLE RUN OF THE NAVMAN MODEL

V. WORK CENTER HOUR BREAKDOWNS

WORK CENTER	SEA CM	SEA PM	SEA AS	SEA OTH	SEA TOT	SHORE CM	SHORE PM	SHORE AS	SHORE OTH	SHORE TOT
010 MAINTENANCE OFFICER	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
020 MAINTENANCE/MATERIAL CO	0.0	0.0	152.1	20.0	172.0	0.0	0.0	135.6	8.5	144.2
030 MAINTENANCE ADMINISTRAT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
040 QUALITY ASSURANCE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
050 MATERIAL CONTROL	0.0	0.0	112.0	17.7	129.7	0.0	0.0	79.5	5.2	84.6
060 DATA ANALYSIS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
100 AIRCRAFT DIVISION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
110 POWER PLANTS BRANCH	193.0	99.4	94.3	50.5	437.3	65.3	34.5	56.1	12.9	168.8
120 AIRFRAMES BRANCH	164.7	106.5	99.0	51.4	421.5	63.1	41.1	58.9	20.9	184.0
121 CORROSION CONTROL	247.5	0.0	50.9	3.2	301.6	99.0	0.0	30.3	1.9	131.2
130 AVIATOR EQUIPMENT	49.6	9.7	48.1	13.2	120.7	19.8	3.9	28.6	1.7	54.1
131 SAFETY EQUIPMENT	37.1	25.3	79.2	15.9	157.6	14.8	10.1	47.1	3.3	75.4
140 PLANNED MAINTENANCE	0.0	0.0	42.4	3.9	46.3	0.0	0.0	25.3	2.3	27.6
200 AVIONICS/ARMAMENT DIVIS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
210 ELECTRICAL BRANCH	249.1	54.4	77.3	68.1	448.9	95.9	21.1	46.0	11.0	174.1
211 ELECTRONIC FIRE CONTROL	261.2	42.3	111.2	74.0	488.8	100.6	16.4	66.2	7.0	190.2
220 ELECTRICAL/INSTRUMENTS	252.1	51.4	101.8	47.4	452.7	89.6	18.6	60.6	11.0	179.8
230 WEAPONS BRANCH	93.6	52.6	73.5	48.1	267.8	31.7	18.3	43.8	3.9	97.6
240 PHOTO SHOP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
300 LINE DIVISION	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
310 PLANE CAPTAINS	148.5	122.8	164.0	155.9	591.3	54.4	45.6	97.7	31.1	228.8
320 TROUBLE SHOOTERS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

MANPOWER SENSITIVITY TO WORKLOAD

WORK CENTER	SEA MINUS HOURS	SEA REQ HOURS	SEA PLUS HOURS	SHORE MINUS HOURS	SHORE REQ HOURS	SHORE PLUS HOURS
110 POWER PLANTS BRANC	40.4	437.3	25.8	31.3	168.8	3.2
120 AIRFRAMES BRANCH	24.6	421.5	41.5	12.0	184.0	22.3
121 CORROSION CONTROL	37.0	301.6	29.2	28.0	131.2	6.4
130 AVIATOR EQUIPMENT	54.5	120.7	11.6	19.7	54.1	14.7
131 SAFETY EQUIPMENT	25.3	157.6	40.9	6.6	75.4	27.7
210 ELECTRICAL BRANCH	52.0	448.9	14.1	2.1	174.1	32.3
211 ELECTRONIC FIRE CO	25.7	488.8	40.4	18.3	190.2	16.1
220 ELECTRICAL/INSTRUM	55.8	452.7	10.4	7.8	179.8	26.5
230 WEAPONS BRANCH	0.0	267.8	771.7	0.0	97.6	428.7
240 PHOTO SHOP	0.0	0.0	0.0	0.0	0.0	0.0
310 PLANE CAPTAINS	0.0	591.3	668.7	22.4	228.8	10.4

V. POSSIBLE NEXT STEPS AND MODEL EXTENSIONS

This report has described NAVMAN, a model that can be used to estimate maintenance personnel requirements for Navy aircraft. The computer program has been validated by checking the output of the entire program and selected individual sections of the program with hand-calculated results. However, a useful further step would be to verify that the model truly replicates the current Navy techniques for estimating personnel requirements. This could be accomplished by obtaining the necessary input data for one or more SQMDs. By using these data as inputs to NAVMAN, the output reports could be verified with the results in the SQMDs. Because the SQMDs include pilot hours and other direct manning hours obtained from operational audits, the SQMD personnel values (or the NAVMAN values) may need to be modified to make the proper comparisons.

As we used the model, we became aware that a number of modifications or extensions might be desirable. Among these are:

- Include the capability to change the number of squadrons along with the number of aircraft when performing sensitivity analysis. This would allow the user to hold the fleet size constant while determining the effects on personnel of various squadron sizes. Originally, only the number of aircraft was considered as a sensitivity variable because there is only a fixed (typically constant) number of carriers and therefore a fixed number of squadrons required. However, we believe that changing the fleet size through changing the number of squadrons may at times prove useful.
- Develop a routine or submodel that would generate work-center maintenance workloads as a function of a wide range of R&M inputs. We attempted to provide as much flexibility as possible in terms of the input data. However, other forms of data may be available and useful. For example, data entered by WUCs are totaled and the total is spread to the

work centers. The model handles WUC data in this fashion because we could not determine a clean crossover from a given WUC to the appropriate work center during our limited analysis. Further research may discover a better way of determining the work-center workloads from detailed WUC data. Because of the potentially large number of various forms of R&M inputs, the generation of maintenance workloads should be separated from the manipulation of the resulting workloads into the personnel requirements.

- Include as part of the overall model a data base of historical R&M values and personnel figures. The capability of referencing and using historical data may prove useful. Typically, for new aircraft, data on preceding systems are used as analogs when estimating personnel requirements. If sufficient data were available in the proper formats, a user could specify a like system or subsystem (with a correction factor for reliability improvements) as the input R&M parameters. We have provided in Volume II some historical R&M data collected during our analysis.

Finally, as has been mentioned previously in this report, it is imperative that the model be kept up to date with all changes in the Navy's personnel estimating methodology. Currently, ACM-02 is being revised and updated. The resulting changes should be incorporated in NAVMAN. The computer program has been constructed in a structured, module fashion to readily permit extensions and updates.