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MANPOWER: A Model of Tactical Aircraft Maintenance Personnel Requirements, Volume I, Overview of Model Development and Application

W. S. Furry, K. M. Bloomberg, J. Y. Lu, C. D. Roach, J. F. Schank

A Report prepared for

OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE/
PROGRAM ANALYSIS AND EVALUATION

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PREFACE

This two-volume report describes the composition, operation, and application of MANPOWER, a PL/I computer model for predicting the base-level (organizational and intermediate) maintenance personnel requirements of prospective U.S. Air Force tactical aircraft.

MANPOWER is a simple model of the complex methods (including the Logistics Composite model, LCOM) used by the Air Force Tactical Air Command (TAC) to determine the maintenance personnel requirements of tactical aircraft. These requirements, usually not estimated by TAC analysts until after a new aircraft has entered full-scale development (that is, after DSARC II), can be predicted by MANPOWER during the concept formulation and validation stages (prior to DSARC II) of system acquisition. The model should be viewed as a *tool* for early forecast and analysis of the total force-wide base-level maintenance personnel requirements of a given tactical aircraft. It does not provide an independent estimate of what the maintenance personnel requirements should be; rather, it provides an estimate of the personnel requirements that will eventually be determined by TAC analysts. The model is limited to predicting the requirements in the traditional TAC AFM 66-1* maintenance organization for aircraft utilization rates ranging from 0.6 to 1.4 sorties per aircraft per day (the sustained flying program). Since this study was conducted under the aircraft maintenance concepts of Air Force Manual 66-1, it does not reflect Air Force policy because it does not reflect requirements of the Production Oriented Maintenance Organization (POMO) Regulation, AFR 66-5, 17 November 1977.

The development of MANPOWER was sponsored by the Directorate of Cost and Economic Analysis, Office of the Assistant Secretary of Defense (Program Analysis and Evaluation). The model is intended primarily for use by that directorate, and by the Cost Analysis Improvement Group (CAIG) which it chairs, in support of the Defense Systems Acquisition Review Council (DSARC). Among the responsibilities of the CAIG and DSARC is critical review of the operating and support

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*Department of the Air Force, *Maintenance Management*, AFM 66-1, Volume I, July 1, 1978.

(O&S) cost consequences of the acquisition of new weapons systems. Maintenance personnel requirements are primary contributors to O&S costs; hence, those requirements by themselves draw critical review. The MANPOWER model and a comparable model for U.S. Navy aircraft* provide a means for the CAIG to prepare estimates of aircraft personnel requirements early in the acquisition review process, to conduct reviews of estimates prepared by the military services, and to explore systematically the effects on those requirements of changes in the principal system and maintenance policy variables.

Although MANPOWER is directed primarily at the needs of the CAIG, it should also be useful to various Air Force offices concerned with the estimation of base-level maintenance personnel needs of new tactical aircraft.

This volume of the report provides a complete description of the structure, inputs, outputs, and applications of MANPOWER. Volume II, *Technical Appendixes*, supplies detailed procedures for determining work center requirements, as well as data bases used to develop and validate the model. Technical documentation of the computer program is available upon request. This material includes an index of variables, a map of subroutines, a dictionary of subroutines and variables, and a program listing.

The Air Force methods and standards incorporated in MANPOWER are current as of midsummer 1978. They are subject to frequent change, however, and the user of MANPOWER should be aware of the need to update the model periodically.

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* *NAVMAN: A Model of Maintenance Personnel Requirements for Navy Aircraft*, B. E. Armstrong, J. F. Schank, and G. R. Blais, The Rand Corporation, R-2402-PA&E, forthcoming.

SUMMARY

MANPOWER is a PL/I computer model that provides an estimate of the total force base-level maintenance personnel requirements of prospective Tactical Air Command (TAC) aircraft. The model is designed for use during the concept formulation and validation stages of weapon system acquisition. It is to be used (along with similar models for different types of weapon systems)* in analyzing the long run personnel implications of alternative approaches to mission accomplishment. MANPOWER meets the need for a model that addresses the maintenance personnel requirements of TAC aircraft early in development, focuses on manning rather than on system reliability and maintainability, and addresses organizational factors as well as hardware characteristics.

To run MANPOWER, the user must supply operations data (such as mission types, sortie rates, and sortie lengths), organizational features (such as deployment patterns, squadron size, and peacetime base sizes), and maintenance characteristics (such as maintenance manhours per flying hour, mean-time-between-failures, and mean-time-to-repair). Model output includes manpower requirements for the total force, for individual base size/deployment patterns, for maintenance squadrons, for officers and enlisted personnel, for overhead and supervision, and for major individual shops and groups of work centers. In addition, MANPOWER permits sensitivity analysis of the maintenance manhour inputs.

A technical appendix (Vol. II) describes the development of manning equations and factors incorporated in MANPOWER. Statistical standards are used by TAC to determine about half the total base-level personnel requirement. Most of these standards have been programmed in MANPOWER without modification; in a few cases, standards have been modified to use information about the weapon system that can be expected to be available during the concept development phase of the acquisition

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*A model of the maintenance personnel requirements for Navy aircraft is being developed: *NAVMAN: A Model of Maintenance Personnel Requirements for Navy Aircraft,* B. E. Armstrong, J. F. Schank, and G. R. Blais, The Rand Corporation, R-2402-PA&E, forthcoming.

process. The other half of the maintenance personnel requirement is determined by TAC analysts using a simulation model known as LCOM (Logistics Composite Model). In MANPOWER, a set of multiple regression equations is used to simplify and generalize LCOM. In these equations, the dependent variable is the manning requirement in an individual shop or in a group of shops; the irdependent variables in these equations are maintenance manhours per sortie, wartime sortie rate, and deployment size (number of aircraft).

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I. OVERVIEW

This report describes MANPOWER, a PL/I computer model for predicting the base-level maintenance personnel requirements of prospective Tactical Air Command (TAC) aircraft. The model was designed to meet the following criteria:

- Use simple, readily available inputs (so that the model can be used by someone who is not an aircraft maintenance expert);
- Be applicable in the concept formulation and concept validation stages of system acquisition (pre-DSARC II);
- Generate below depot personnel requirements for the total force in the five maintenance divisions (Chief of Maintenance, Organizational, Field, Avionics, and Munitions maintenance squadrons);
- Be sensitive to changes in peacetime basing, wartime deployment patterns, squadron size, wing size, and flying program factors as well as to changes in reliability and maintainability.

NEED FOR THE MODEL

This model was produced as part of a long term effort to develop analysis tools to aid the Cost Analysis Improvement Group (CAIG) in making and evaluating estimates of the maintenance personnel requirements of new weapon systems.* The project has addressed three problems identified by the CAIG as requiring attention.

First, the personnel implications of new systems should be considered as early as possible in the acquisition process. Usually, the total maintenance personnel requirements of a new system are not systematically evaluated until full-scale engineering has begun. Our goal has been to estimate the total force maintenance personnel

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

needs of new weapons during the concept formulation phase of the acquisition decisionmaking process.

Second, early estimates of the maintenance requirements of a new weapon system should be in terms of manning rather than system reliability and maintainability (R&M). Traditionally, in the early stages of acquisition, the maintenance requirements of a new weapon system have been expressed in terms of mean-time-between-failures (MTBF), mean-time-to-repair (MTTR), or maintenance manhours (MMH) per operating hour. These traditional measures fail to give visibility to the actual personnel and cost implications of an operational force of a new weapon system.

Third, a significant problem with the traditional reliability and maintainability 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 impact on personnel requirements of such factors as operational unit size, peacetime basing and wartime deployment patterns, the rate of use of the weapon system, maintenance crew size requirements, shift coverage requirements, and the organization of occupational specialties. In short, the influence of organizational and program factors on personnel requirements often has been overlooked in the effort to reduce manning by improving hardware reliability and maintainability.

KEY MODEL FEATURES

User inputs:

- Aircraft type (reconnaissance, fighter, or attack).
- Avionics type ("integrated" or "nonintegrated").
- Number of shops in the Avionics Maintenance Squadron.
- Aircraft per squadron.
- Alert aircraft per squadron.
- Peacetime base sizes.
- Wartime deployment patterns.
- Wartime and peacetime sortie rates.

- o Wartime and peacetime sortie lengths.
- o MMH requirements in one of the following formats:
  - Maintenance manhours per flying hour (MMH/FH) in four work center groups.
  - Maintenance manhours per sortie (MMH/S) in seven first-digit work unit code categories.
  - Mean-time-between-failures and mean-time-to-repair in 37 second-digit work unit code categories.
  - Mean-time-between-failures, mean-time-to-repair, and workload distribution factors in 37 second-digit work unit code categories.
- o Increments for sensitivity analysis.

Model processes:

- o Evaluation of simplified manning standards to determine manning in work centers whose requirements are currently determined by TAC using traditional workload manning techniques.
- o Evaluation of multiple regression equations that model the Logistics Composite Model (LCOM) used by TAC to simulate the maintenance organization.
- o Calculation of peacetime and wartime requirements (where possible) and allocation of the larger.
- o Insurance of minimum manning in LCOM shops.
- o Determination of requirements for one or more squadrons deploying to separate locations during wartime.

Model outputs:

- o Total force personnel requirements; total personnel for shops whose requirements are determined by TAC using the LCOM simulation model; and total personnel for shops whose requirements are determined by TAC using statistical standards.
- o Officer and enlisted personnel requirements.
- o Peacetime and wartime requirements in the LCOM and "standard manned" shops.

- o Personnel requirements at the maintenance squadron level for each deployment pattern specified by the user.
- o Optional printout of LCOM, standard, and overhead requirements for each maintenance squadron for each deployment pattern.
- o Optional sensitivity analyses of total force and individual deployment pattern requirements.
- o Notification when values of independent variables are outside the range of values used to derive the estimating equations.

PRECAUTIONS IN MODEL APPLICATION

Maintenance Manhour Inputs

User-supplied estimates of maintenance manhour requirements (MMH/FH, MMH/S, or mean-time-to-repair) must include all tasks that are simulated in an LCOM study. These are troubleshooting, obtaining access, jacking, getting and hooking up support equipment, removing and replacing components, inspecting, repairing on-aircraft, verifying system works, aircraft handling and towing, loading and downloading, checking and repairing components, and disassembling and assembling.* The analyst should remember that he is using estimates of the independent variables in a regression equation, which itself is an estimate of a linear function. Sensitivity analysis of the maintenance manhour inputs is an essential part of the application of MANPOWER.

Model Revision

The estimating relationships and standards in this model reflect current TAC procedures and assumptions for determining personnel requirements. It should be remembered that these procedures are continuously evolving. New statistical standards are being developed, more tasks are being included in the LCOM simulation, and new work centers are being simulated. The statistical standards in MANPOWER should be periodically reviewed and updated. When simulation replaces statistical standards (such as in Munitions Maintenance), new regression equations will have to be developed.

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*The best introduction to LCOM is contained in Major Kenneth R. Keller, *Logistics Composite Model Student Training Text*, 4400 MES/LC, Langley Air Force Base, Virginia, July 1977.

Accuracy of the Estimate

The total personnel estimate for a base or an entire force is the sum of requirements determined by traditional statistical standards and by LCOM simulation (both subtotals are given in the basic output of MANPOWER; more detail is provided in optional output). Statistical standards currently used by TAC have been incorporated in most cases in MANPOWER exactly as they are applied by TAC; in a few instances, the standards have been modified slightly so they can be used with information normally available during the early stages of system acquisition. For the most part, then, MANPOWER's prediction of requirements for "standard-manned" shops will be the same as those estimated by TAC when identical values are used for the independent variables in the statistical standards. These independent variables are flying program attributes such as flying hours per month, sortie rates, and units of equipment (UE).* Thus, the analyst should be alert to potential errors stemming from incorrect assumptions about flying-program variables.

The requirements for shops that TAC simulates using LCOM are predicted in MANPOWER by linear multiple regression equations. We noted above that one source of error for these predictions is in the estimate of the values of the independent variables in these equations (in particular, in the estimate of $\overline{MMH/S}$). Another source of error is, of course, in the equations themselves, which are estimates of linear functions based on sets of sample observations. The coefficients of determination (R^2) are good (between .70 and .96--see Table 4, pp. 20-21); also, all the equations and coefficients are significant at .01. However, the standard errors of the estimate are fairly large for Aerospace Systems and Avionics Maintenance personnel; they are much smaller for Jet Engine and Organizational Maintenance (see Table 4). The mean percentage deviation of the predicted values from the observed values in the sample data sets is roughly 8 percent for Organizational Maintenance, 10 percent for Jet Engine Shop, 25 percent for Aerospace Systems and Structural Repair, 25 percent for traditional "nonintegrated" avionics shops, and 35 percent for advanced "integrated" avionics shops. The primary reason for the large percentage deviations for

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*The Air Force is nov "PAA" in place of the tra of aircraft at a base or

Aerospace Systems and "nonintegrated" avionics shops is that these are often minimum manned; thus, the predicted requirements (which are based on a small workload) often are substantially less than the actual minimum requirements. MANPOWER adjusts for this bias by allocating minimum manning for these shops whenever necessary (see p. 22 and the companion report,* App. D). Advanced "integrated" avionics shop requirements have exhibited great variation and the analyst should emphasize the uncertainty of his predictions in this area.

ORGANIZATION OF THIS REPORT

Section II describes the most important procedures and assumptions incorporated in MANPOWER. Section III discusses model inputs and presents an illustrative case. Section IV describes the validation of MANPOWER and outlines areas for additional development. The Appendix in this volume contains format statements for the input card deck.

A technical appendix (Vol. II) presents detailed descriptions of procedures to determine work center requirements. Also, it contains the LCOM data base and the detailed results of a model validation exercise using new A-10 and F-4E data.

Technical information concerning the PL/I computer program is available from The Rand Corporation upon request.

***MANPOWER: A Model of Tactical Aircraft Maintenance Personnel Requirements, Volume II, Technical Appendixes*, W. S. Furry, K. M. Bloomberg, J. Y. Lu, C. D. Roach, J. F. Schank, The Rand Corporation, R-2358/2-PA&E, April 1979.

II. MODEL DEVELOPMENT AND STRUCTURE

INTRODUCTION

The dependent variable in this modeling effort is the number of people who eventually will be determined by TAC analysts as required to maintain a fleet of new tactical aircraft.

The principal independent variables upon which this prediction is based are number of aircraft, number of sorties per aircraft per day, average sortie length, MMH/FH or MMH/S, mean-time-between-failures, mean-time-to-repair, peacetime base size, wartime deployment pattern, and aircraft per squadron.

TAC maintenance personnel "standards," personnel authorizations at TAC bases, and the results of LCOM simulation studies for the A-7D, RF-4C, F-4E (1973), F-4E (1978), A-10, F-111D, and F-16 were analyzed to derive the generic estimating equations incorporated in MANPOWER. Complete descriptions of all data bases and samples are contained in the technical appendix (Vol. II).

TAC MAINTENANCE PERSONNEL REQUIREMENTS

Since our goal was to predict the maintenance personnel requirements of new TAC aircraft, we had to understand TAC's personnel planning procedures. In this section, we outline this methodology and describe how we have simplified and generalized these procedures to estimate the manning of new aircraft early in the acquisition process.

The Office for Plans, Manpower and Organization (XPM), at TAC Headquarters, Langley Air Force Base, oversees the estimation of maintenance personnel requirements. The unit of analysis in this personnel planning is the "work center," also known as a "shop." There are roughly fifty work centers in the maintenance complex that specialize in activities such as fuel system repair, gun services, quality control, radio repair, and asset control.

There are three types of TAC personnel requirements, which we categorize according to how they are determined: (1) LCOM standards, (2) statistical standards, and (3) manning guides and aircraft maintenance manpower requirements (AMMRs). LCOM standards are derived using the computerized Logistics Composite Model, which simulates aircraft operation, failure, and repair during a typical combat scenario. Statistical standards consist of linear regression models that relate measured or reported manhour requirements to workload factors (such as sorties or flying hours). Manning guides and AMMRs are relatively informal estimates of personnel requirements in occupations where more systematic methods of analysis are impractical or not feasible: they include such positions as shop overhead and supervision, which comprise 5 to 8 percent of the total wing maintenance personnel requirement.

Table 1 suggests the relative importance of statistical standards and LCOM standards in the manning of TAC aircraft maintenance. (The personnel allocated according to manning guides and AMMRs are included

Table 1

TOTAL MAINTENANCE PERSONNEL REQUIREMENTS DETERMINED BY STATISTICAL STANDARDS AND LCOM FOR SELECTED AIRCRAFT[a]

Aircraft	UE[b]	Total Manning	Total LCOM Manned	Total Standard Manned[c]	Percentage Standard Manned	Year of LCOM Study
F-4E	72	1388	596	792	57.1	1973
RF-4C	54	788	403	385	48.9	1975
F-111D	72	1979	961	1018	51.4	1976
A-7D	72	1383	542	841	60.8	1976
F-16	72	1482	744	738	49.8	1976
A-10	72	1211	594	617	50.9	1978
F-4E	72	1469	827	642	43.7	1978

[a]This manning is representative; it depends on assumptions concerning the utilization scenario and other variables.

[b]Two-way deployment assumed. (The aircraft are assumed to be organized in three squadrons of 24 UE--18 UE for the RF-4C--with two squadrons deploying to one location and the third to another in event of war.)

[c]Includes personnel allocated according to manning guides and AMMRs (roughly 100 people).

in the "standard manned"* total because these requirements are based on nonsimulation analysis techniques.) It can be seen that 43 to 60 percent of the total manning currently is determined using traditional nonsimulation methods, and 40 to 57 percent is allocated using the newer simulation technique.

The LCOM simulation has been adopted by Air Force maintenance personnel planners because it links manning in a work center with the aircraft sortie rate; in contrast, the traditional statistical methodology links personnel with the maintenance workload. LCOM manning theoretically guarantees some level of operational capability; statistical standards guarantee some level of maintenance capability. LCOM manning is sensitive to the *timing* of the workload and requires that additional personnel be allocated when the workload increases during peak flying periods. Statistical manning is a function of the total workload during a time period. For those shops manned by statistical standards, it is assumed implicitly that work can be deferred without degrading the sortie rate; hence, extra personnel are not necessary during peak flying periods.

The LCOM technique has been applied to those shops that are most important for the achievement of the flying goal. These work centers typically are engaged in work directly on aircraft systems and components. Statistical standards, on the other hand, are still used for shops that provide support for the direct labor. For example, the fuel system repair shop is manned by LCOM simulation, whereas the manning needed to repair and inspect aerospace ground equipment (AGE) is determined using a statistical standard. LCOM has been used for shops where the workload is directly influenced by aircraft reliability (mean-time-between-failures) and maintainability (mean-time-to-repair). Statistical standards are considered satisfactory for shops where the workload is relatively insensitive to aircraft R&M. To an important degree, the personnel requirements of the nonsimulated shops are independent of the physical characteristics of the aircraft (Chief of Maintenance is the best example of this).

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*Work centers manned by nonsimulation techniques are frequently referred to by TAC analysts and others as "standard manned" shops. This usage is employed in the following pages.

In the following two subsections, we present an overview of how "standard manned" and LCOM simulated shops have been incorporated in MANPOWER. (Detailed descriptions of the manning equations are contained in the technical appendix.) Figures 1-5 depict the five principal subdivisions of the current TAC aircraft maintenance organization and the type of manning found in each work center.

WORK CENTERS MANNED BY STATISTICAL STANDARDS*

It can be seen in Figs. 1-5 that all maintenance squadrons have at least a few work centers where requirements are determined by traditional statistical methods.

Statistical standards are based on a variety of conventional work analysis techniques including time study, work sampling, standard data, operational audit, and record analysis.† Linear regression is used by TAC analysts to develop a prediction equation that relates the shop workload (expressed in manhours) to a program variable (such as flying hours, sorties, or units of equipment). The manpower requirement for a given shop is calculated by dividing the predicted workload by the number of hours an individual worker is available for productive labor (144 hours a month in peacetime and 242 hours a month in wartime).‡

The adaptation of the statistical standards for MANPOWER was relatively straightforward. For most work centers, the regression equations developed by TAC analysts were programmed in MANPOWER without modification. The personnel requirement for each of the "standard manned" work centers is calculated individually, with the

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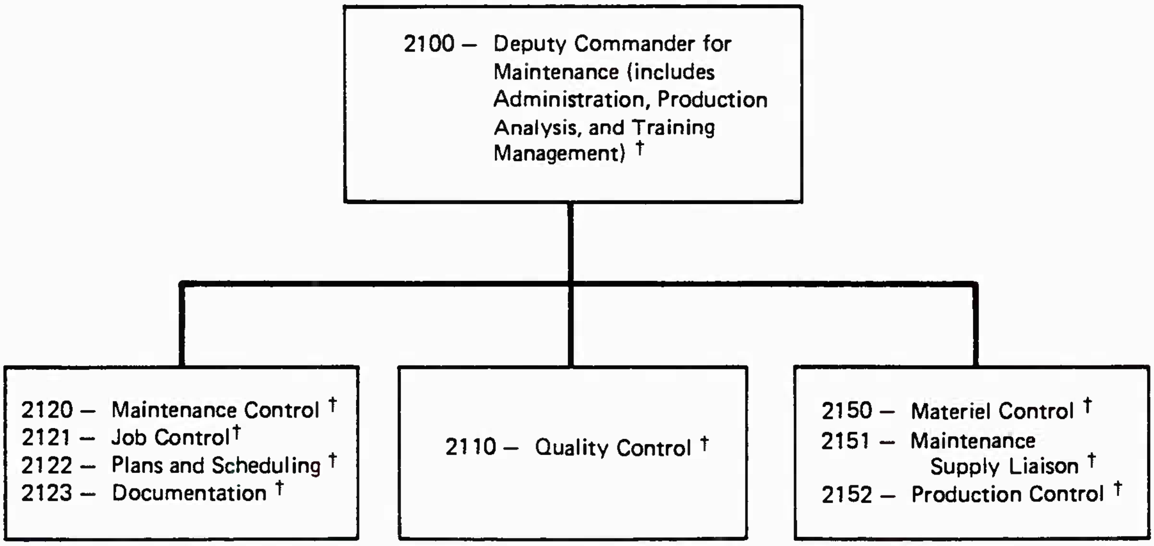
*Included under this heading are allocations according to manning guides (for overhead and supervisory personnel) and AMMRs (specifically, Corrosion Control and Electronic Countermeasure (ECM) pods).

†This methodology is described in *Management Engineering Policies and Procedures*, Department of the Air Force, AFM 25-5, 8 August 1973.

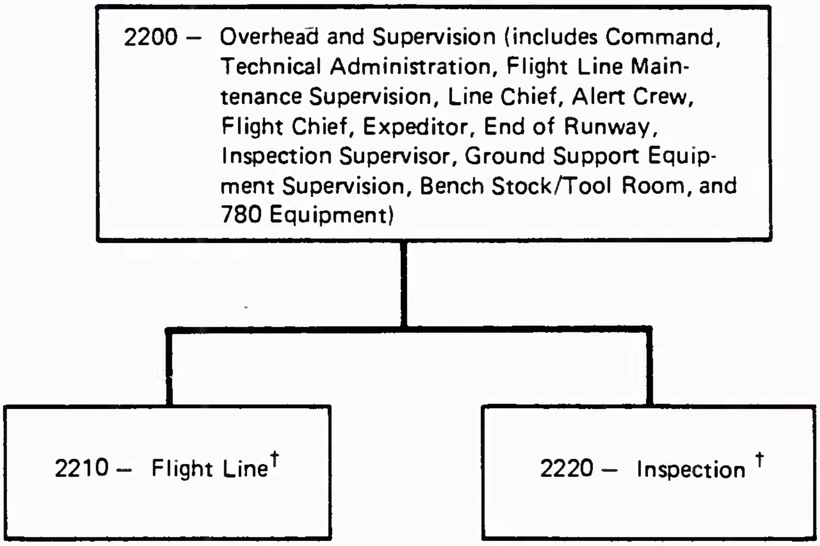
‡For a few work centers in Munitions Maintenance, the statistical standards directly relate the number of personnel required, rather than the manhours required, to the workload factor.



*In Chief of Maintenance, none of the shops are simulated.

†Shops for which peacetime requirements currently are calculated.

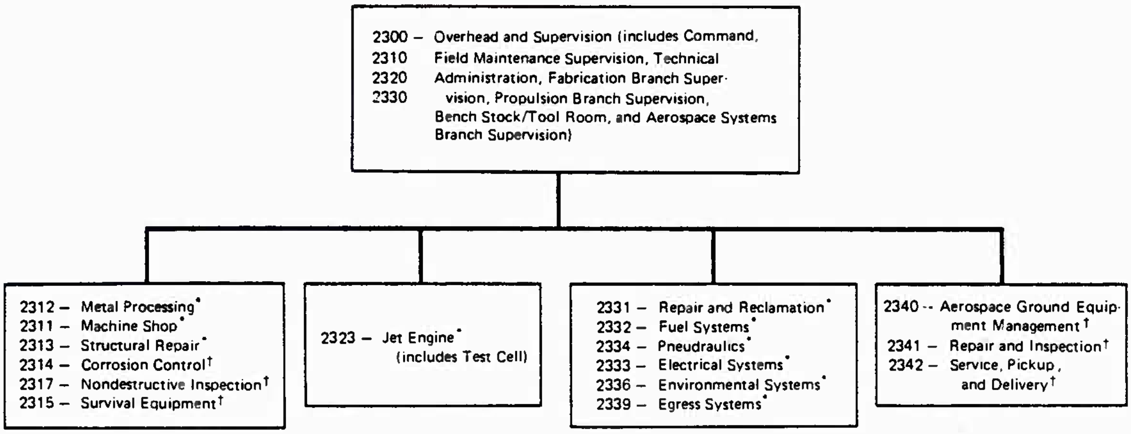
Fig. 1 — Work centers in Chief of Maintenance*



*In Organizational Maintenance, peacetime requirements are not calculated.

†LCOM simulated (all others not simulated).

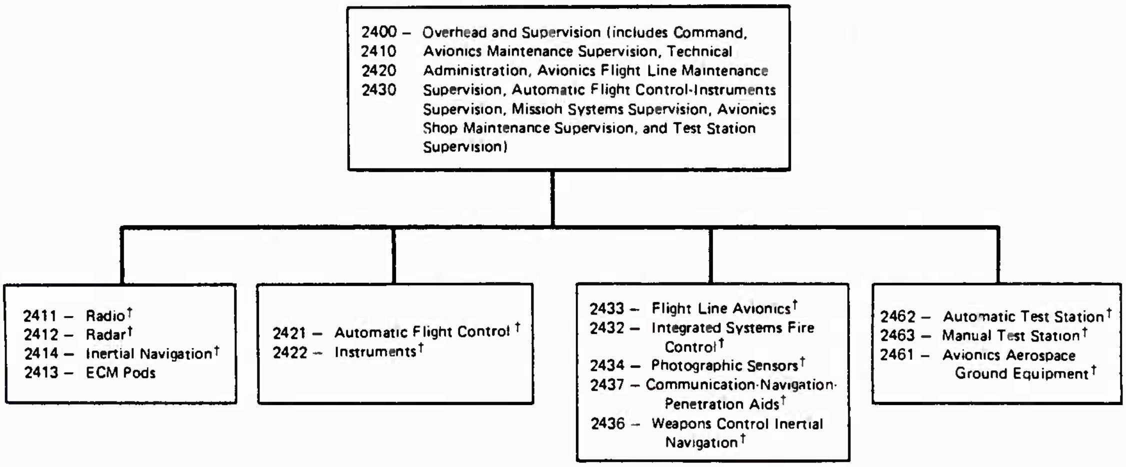
Fig. 2 — Work centers in Organizational Maintenance*



*LCOM simulated (all others not simulated).

†Shops for which peacetime requirements currently are calculated.

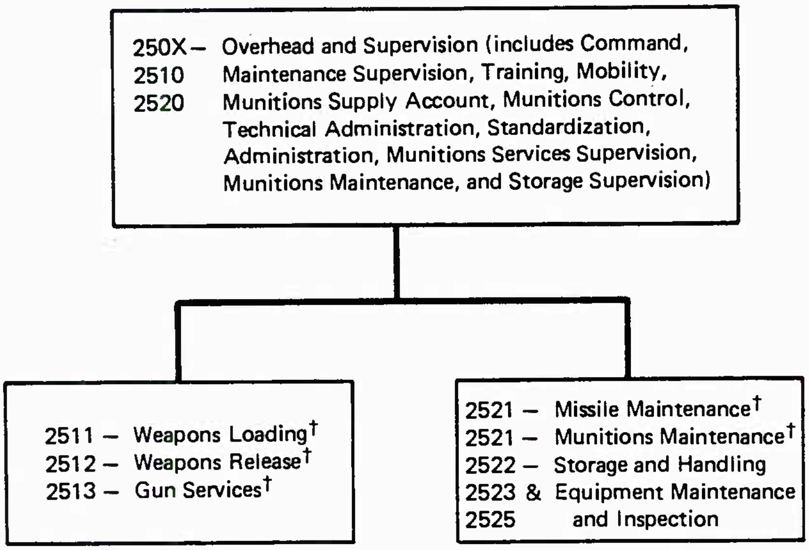
Fig. 3 — Work centers in Field Maintenance*



* In Avionics Maintenance, peacetime requirements are not calculated.

† LCOM simulated (all others not simulated).

Fig. 4 — Work centers in Avionics Maintenance*



*In Munitions Maintenance, peacetime requirements are not calculated.

†These shops have been simulated in the latest LCOM studies (F-16, A-10, and F-4E).

Fig. 5—Work Centers in Munitions Maintenance*

exceptions of (1) Munitions Supply Accountability and Munitions Control and (2) Equipment (Trailer) Maintenance and Munitions Inspection. These small work centers are manned jointly. Table 2 lists the equations and manning constraints incorporated in MANPOWER for each standard manned shop. The technical appendix (Vol. II) presents detailed descriptions of all standard manned work centers and discusses the specific considerations underlying each of the calculation procedures.

Typically, the program factors in the statistical standards can be stipulated early in the acquisition process: For example, programmed wartime sortie rates and flying hours per month are substantially independent of a new aircraft's maintainability and reliability. For a few work centers, however, the standard workload factors could not easily be estimated before the DSARC II decision (for example, the number of various types of nondestructive inspections). In this situation, we examined the actual *authorizations* for the work center at representative bases and regressed this manning against

Table 2

WORK CENTER MANNING STANDARDS IN MANPOWER

Work Center Number	Work Center Name	Manning Equation[a]
2100	Deputy Commander for Maintenance	Y[b] = (2125.60 + .5032 (flying hours))/MA[c]
2110	Quality Control	Y = (3477.2 + .7469 (sorties))/MA
2120	Maintenance Control Management	Y = 4
2121	Job Control	Y = (1082.7 + 1.143 (flying hours))/MA
2122	Plans and Scheduling	Y = (532.8 + 1.0813 (sorties))/MA
2123	Documentation	Y = (264.2 + 6.393 (UE))/MA
2150	Materiel Control Management	$Y = (19.18\ (\text{sorties})^{.4269})/MA$
2151	Maintenance Supply Liaison	Y = (505.8 + 1.013 (sorties))/MA
2152	Production Control	Y = (713.7 + .9658 (sorties))/MA
2314	Corrosion Control	Y = .92 + .14(UE)
2315	Survival Equipment	Y = 3.02 + .12(UE)
2317	Nondestructive Inspection	Y = 4.48 + .14(UE)
2340	AGE Management[d]	Y = f(UE)
2341	AGE Repair and Inspection[d]	Y = (6.2 (sorties))/MA or Y = (3.49 (sorties))/MA
2342	AGE Service, Pick-up, and Delivery[d]	Y = (7.9 (sorties))/MA or Y = (4.44 (sorties))/MA
2413	ECM Pods	Y = .42(UE)
2200	Organizational Maintenance Overhead and Supervision[d]	Y = f(UE)
2300	Field Maintenance Overhead and Supervision[d]	Y = f(UE)
2400	Avionics Maintenance Overhead and Supervision[d]	Y = f(UE)
2501	Munitions Maintenance (MM) Commander	Y = 2
2502	Maintenance Supervision	Y = 3
2503	Training Management	Y = 2
2504	Mobility Administration	$Y = (133.1 - .11(P_1) + .0008048(P_1)^2)/MA$ where, P_1 = total personnel in all other munitions maintenance work centers

Table 2 (cont'd.)

Work Center Number	Work Center Name	Manning Equation[a]
2505	Munitions Supply and Munitions Control	$Y = 6.25 + .06(P_2) + 2.38(K)$ where, P_2 = total personnel in 2521 (Munitions and Missile Maintenance) and 2522 (Storage and Handling); K = 1 if the aircraft has an air superiority mission, otherwise K = 0
2506	Technical Administration	$Y = 2$
2507	Standardization	$Y = 6$
2508	Administration	$Y = (2.01(P_1)^{.9889})/MA$
2510	Munitions Services	$Y = 2$
2511	Weapons Loading	$Y = 2(UE) + 4$(number of squadrons)
2512	Weapons Release	Y = f(UE, wartime sortie rate)
2513	Gun Services	Y = f(UE, wartime sortie rate)
2520	Maintenance and Storage	$Y = (P_3/(.06646 + .001186(P_3)))/MA$ where, P_3 = total personnel in 252x (excluding 2520)
2521	Missile and Munitions Maintenance	Y = f(UE, wartime sortie rate, air superiority missions)
2522	Storage and Handling	Y = f(UE, wartime sortie rate, air superiority missions)
2523 and 2525	Equipment Maintenance and Inspection	$Y = (.12057)(P_2)$.

[a]These equations are applied subject to the condition that minimum wartime requirements are guaranteed. For certain work centers, specific wartime minimums for a deployment unit have been specified in contingency standards. For other work centers, the manning equation must be applied once for each deployment unit at a peacetime base. For example, the requirement for a wing of three squadrons to be deployed two-ways in war will equal the requirement for one squadron plus the requirement for two squadrons. See the technical appendix for the precise manning procedures in each case.

[b]Y = the number of personnel required.

[c]MA = Manpower availability. During peacetime this usually is 144 hours/person/month; during wartime, usually 242 hours/person/month.

[d]See the technical appendix (Vol. II) for the exact specification of these equations.

a program variable (such as UE) to find a simple predicting equation. This procedure was followed for all work centers where an applicable statistical standard did not exist: Corrosion Control, Nondestructive Inspection, Survival Equipment, Munitions Supply Accountability, Munitions Control, Equipment (Trailer) Maintenance, Munitions Inspection, and Munitions Maintenance for reconnaissance aircraft.

Another potential problem was the use of different standards for different aircraft types. Fortunately, we found that most standards were applied uniformly across aircraft types. Three types of exceptions were treated as follows: First, small differences (of one or two positions) across aircraft types were ignored; the modal value for the work center was adopted in MANPOWER (for example, in the technical appendix see Quality Control). Second, in several work centers reconnaissance aircraft require fewer personnel because of mission differences and their lower sortie rate. The lower requirement for reconnaissance aircraft was explicitly incorporated in the model (for example, in Aerospace Ground Equipment-234X). Finally, the F-111 has had numerous unique maintenance problems that have created a requirement for extra *indirect* personnel. These "additives" have not been incorporated in the computer model. However, the analyst should recognize that additional Chief of Maintenance personnel as well as mechanics will be required when exceptional maintenance problems occur.

In the latest LCOM simulation studies (e.g., the A-10 and the F-4E update), some work centers in the Munitions Maintenance Squadron have been simulated. Nevertheless, the requirements for these work centers are determined in MANPOWER using the traditional standards. In the validation of Version 1 of MANPOWER (see the Appendix to this volume) these standards produced acceptable predictions. When more simulations of the Munitions Maintenance shops become available, new equations like those determined for the other LCOM shops (described in the following subsection) should be developed.

WORK CENTERS MANNED BY LCOM SIMULATION

The Logistics Composite Model simulates the aircraft operational and maintenance environment. The user must supply data describing squadron or wing size, mission types and corresponding weapon system configurations, sortie lengths, takeoff times, frequency of parts failure, repair times, and the required personnel, spare parts, test equipment, and other resources. The computer generates reports showing the degree of operational capability achieved during the simulation, the time distribution of the workload, and the personnel needed to support the desired level of operation. In an LCOM study, the analyst adjusts the manning of individual work centers to determine the minimum number required each 24 hour period to guarantee accomplishment of the sortie rate goal.*

The results of LCOM simulation studies of the F-4E (1973 and 1978 studies), A-7D, F-111D, RF-4C, A-10, and F-16 were available for this study.† Table 3 shows the aircraft and the work centers that have been manned by LCOM simulation.

LCOM requires an enormous amount of maintenance data and this detailed information is not available before the advanced development stage (DSARC II) of system acquisition. Our problem has been to discover how to obtain a reasonable estimate of the results of an LCOM simulation without having the detailed data it requires. In essence, our goal has been to "model the modeler."

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*A good description of the LCOM methodology is contained in *Logistics Composite Model (LCOM) Workbook*, Air Force Test and Evaluation Center, Kirtland Air Force Base, New Mexico, June 1976.

†The LCOM results for the F-4E, A-7D, RF-4C, A-10, and F-111D were obtained from the Management Engineering System Analysis Team, Office of the Directorate of Manpower and Organization (XPM), Headquarters, Tactical Air Command, Langley Air Force Base, Virginia. The results of the October 1976 LCOM study of the F-16 were obtained from Headquarters, Aeronautical Systems Division (AFSC), Wright-Patterson Air Force Base, Ohio. An F-15 LCOM report was not available at the time of this study.

Table 3

WORK CENTERS MANNED BY LCOM FOR VARIOUS AIRCRAFT

Work Center	Aircraft Mission/Design/Series						
	F-4E (1973)	F-4E (1978)	A-7D	RF-4C	F-111D	F-16	A-10
<u>Organizational Maintenance</u>							
Flight Line Maintenance	x	x	x	x	x	x	x
Inspection	x	x	x	x	x	x	x
<u>Field Maintenance</u>							
Machine Shop	x	x	x	x	–	–	x
Metal Processing	x	–	x	x	–	–	–
Structural Repair	x	x	x	x	x	x	x
Fuel Systems	x	x	x	x	x	x	x
Electrical Systems	x	x	x	x	x	x	x
Pneudraulics	x	x	x	x	x	x	x
Environmental Systems	x	x	x	x	x	x	x
Egress Systems	x	x	x	x	x	x	x
Repair and Reclamation	–	x	–	–	–	–	x
Jet Engine	x	x	x	x	x	x	x
<u>Avionics Maintenance</u>							
Radio	x	x	x	x	–	–	x
Radar	x	x	x	x	–	–	x
Doppler-Inertial Navigation	x	x	x	x	–	–	–
Automatic Flight Control	x	x	x	x	–	x	x
Instruments	x	x	x	x	–	–	x
Integrated System Fire Control	x	–	x	–	–	–	–
Photo Reconnaissance	x	x	x	x	–	–	x
Sensors	–	–	–	–	–	–	x
Flight Line Avionics	–	–	–	–	x	–	–
Automatic Test Stations	–	–	–	–	x	x	–
Manual Test Stations	–	–	–	–	x	–	–
Avionics AGE	–	–	–	–	–	x	–
Weapons Control-Inertial Navigation	–	x	–	–	–	x	x
Communication-Navigation-Penetration Aids	–	–	–	–	–	x	–
Electronic Warfare	–	x	–	–	–	–	x
<u>Munitions Maintenance</u>							
Weapons Loading	–	–	–	–	–	–	x
Weapons Release	–	x	–	–	–	–	x
Gun Services	–	x	–	–	–	–	x
Missile Maintenance	–	x	–	–	–	–	–
Storage and Handling	–	x	–	–	–	–	–
Munitions Maintenance	–	x	–	–	–	–	–

We found that acceptable (using standard measures of fit such as R^2 and the Standard Error of the Estimate) estimates of the LCOM requirements could be obtained by multiple regression: The dependent variable is the manning requirement in a shop (or group of shops) and the independent variables are the technological, operational, and organizational factors that we believe are important for personnel requirements. The considerations that led to the final aggregation of work centers and to the selection of specific equations are documented in the technical appendix (Vol. II). The equations and work center groups are summarized in Table 4.

The following features should be emphasized:

1. Prediction equations have been determined in four areas: Flight Line and Inspection, Jet Engine shop, Field Maintenance shops, and Avionics Maintenance shops.
   a. Flight Line and Inspection work centers have been combined in one equation that predicts the total personnel requirement for both shops.
   b. The Jet Engine shop has its own prediction equation.
   c. The Field Maintenance equation is for a single work center. It is applied by using the average MMH/S for the seven field shops. (The average MMH/S equals the calculated MMH/S, or the user input MMH/S, for the seven shops together divided by seven.) The resulting personnel requirement for one shop is multiplied by seven to yield the total LCOM shop requirement in Field Maintenance.
   d. The Avionics Maintenance equation is also for a single work center. Its application is identical with that for Field Maintenance except the number of shops is a user input value.
2. The independent variables in the equations are MMH/S, wartime sortie rate (SRW), and deployment size (in UE).

Table 4

SUMMARY OF PREDICTING EQUATIONS FOR LCOM SHOPS IN MANPOWER[a]

Work Centers	Prediction Equation
1. Organizational Maintenance (Flight Line and Inspection)	*LN* MR[b] = −.34942 + .82402 (*LN* MMH/S) + 1.03783 (*LN* SRW) + .81250 (*LN* UE) 1. Range of values in data set: MMH/S = 8.3 to 25.5; UE = 18 to 72; SRW = .64 to 1.36 2. Statistics:[c] N = 27; R^2 = .949; F ratio LS > .99; all coefficients significant at .001; standard error of estimate = .11
2. Jet Engine Shop	*LN* MR = −.53760 + .81638 (*LN* MMH/S) + 1.33738 (*LN* SRW) + .83800 (*LN* UE) 1. Range of values in data set: MMH/S = 2.1 to 11.0; UE = 18 to 72; SRW = .64 to 1.36 2. Statistics: N = 27; R^2 = .957; F ratio LS > .99; all coefficients significant at .001; standard error of estimate = .14
3. Aerospace Systems, Repair and Reclamation, and Structural Repair (Fuel Systems, Electrical Systems, Pneudraulics, Environmental Systems, Egress Systems, Structural Repair, and Repair and Reclamation)	*LN* MR[d] = .75348 + .50141 (*LN* MMH/S/7) + .73856 (*LN* SRW) + .48210 (*LN* UE) 1. Range of values in data set: MMH/S/7 = .1 to 4.9; UE = 18 to 72; SRW = .64 to 1.36 2. TOTAL MR = $7(e^{LN\ MR})$ 3. Statistics: N = 179; R^2 = .700; F ratio LS > .99; all coefficients significant at .001; standard error of estimate = .31.

[a] The manpower requirement is calculated for each deployment unit. Total peacetime base requirement equals the sum of the requirements for each deployment unit. For example, the requirement for a wing of three squadrons to be deployed two-ways in war will equal the requirement for one squadron plus the requirement for two squadrons.

[b] MR = manpower requirement; SRW = sortie rate wartime; LS = level of significance.

[c] In statistical notation, N = number of observations included in regression analysis.

[d] In Aerospace Systems, Repair and Reclamation, and Structural Repair, Integrated Avionics, and Nonintegrated Avionics, the equation calculates an average requirement for one shop; this value must be multiplied by the number of shops to determine the TOTAL MR.

Table 4 (Cont.)

Work Centers	Prediction Equation
4.[e] Nonintegrated Avionics (Radio, Radar, Doppler Inertial Navigation, Automatic Flight Control, Instruments, Integrated Systems-Fire Control, Photo Reconnaissance, Sensors, Electronic Warfare, and Weapons Control)	*LN* MR = .49871 + .59401 (*LN* MMH/S/N) + .74323 (*LN* SRW) + .51923 (*LN* UE) 1. N = Number of shops (user input). 2. Range of values in data set: MMH/S/N = .1 to 10.9; UE = 18 to 72; SRW = .64 to 1.36 3. TOTAL MR = $N(e^{LN\ MR})$ 4. Statistics: N = 190; R^2 = .811; F ratio LS > .99; all coefficients significant at .001; standard error of estimate = .30
5.[e] Integrated Avionics (Automatic Test Stations, Flight Line Avionics, Avionics AGE, Weapons Control-Inertial Navigation, Automatic Flight Control/Instruments and Communication-Navigation-Penetration Aids)	*LN* MR = .9000 + .62290 (*LN* MMH/S/N) + .52003 (*LN* UE) 1. N = Number of avionics work centers (user input). 2. Range of values in data set: MMH/S/N = .1 to 24.8; UE = 18 to 72; SRW = .67 to 1.0 3. TOTAL MR = $N(e^{LN\ MR})$ 4. Statistics: N = 14; R^2 = .878; F ratio LS > .99; UE significant at .16; MMH/S significant at .001; standard error of estimate = .45
6. Machine Shop and Metal Processing	1. If aircraft type = Reconnaissance, MR (machine shop) = 2 MR (metal processing) = 2 2. If Aircraft type ≠ Reconnaissance, MR (machine shop) = 6 MR (metal processing) = 4

[e] See p. 29 for a discussion of the differences between integrated and nonintegrated avionics.

a. MMH/S is either user input or calculated based on user inputs. (The alternative methods for inputting the workload are described later in this section.) MMH/S represents the reliability and maintainability of the prospective aircraft. Generally, the lower the R&M of the aircraft, the higher the MMH/S and the higher the personnel requirement.

b. The SRW is the average number of sorties per aircraft per day during a sustained wartime flying program. The higher the sortie rate, the more sorties per day, and the higher the personnel requirement. Also, the higher the sortie rate, the more work that must be accomplished simultaneously, and therefore, the more personnel required at any one time.

c. The deployment size (in UE) is the number of aircraft in a deployable unit for which a personnel requirement is determined (see item 4, below). In general, the more aircraft in a squadron, the larger the personnel requirement.

3. The minimum personnel requirement in Field Maintenance and Avionics Maintenance is six per shop. Thus, if the equations generate an average requirement of less than six, the actual requirement will equal six times the number of shops. This allows two persons per shift for three shifts, which is the typical requirement in many low workload shops.

4. The personnel requirement for each deployment unit (which is to be sent to a separate location in a war) is calculated individually; the sum of these deployment requirements equals the total LCOM shop requirement at the peacetime base.

5. Machine Shop and Metal Processing are nearly always manned at minimum levels, whether they are simulated or not. In MANPOWER, average values are used for these two small shops.

CALCULATION PROCEDURES

The statistical standards and LCOM regression equations described in the preceding sections are the basis for all work center personnel predictions. In addition, however, MANPOWER implements many important decision rules that influence the manning requirement. These procedures and other features of the model are described in the following subsections.

Workload Inputs

To calculate the LCOM work center personnel requirements, an estimate of MMH/S is required. The user has four options to input this information, progressing from little to great detail:

1. MMH/FH. The user can provide MMH/FH for each of the four work center groups. This is converted to MMH/S by: MMH/S = MMH/FH x FH/S (flying hours per sortie), where FH/S is a user input.
2. MMH/S. The user can provide MMH/S in seven work unit code categories listed in Table 5. MANPOWER applies distribution factors to allocate these work unit code MMH/S to the four work center groups. The factors shown in Table 5 were derived from recent AFM 66-1* maintenance data for ten aircraft types (F-111A and D, F-4C, D, and E, A-7D, F-105G, F-15, F-106, and RF-4C). The factors represent average values for the percentage of maintenance hours in each work unit code category that was performed in the four work center groups. The variation in these percentages among aircraft types, as indicated by the AFM 66-1 data, was not great; it amounted to the manhour equivalent of less than five personnel for any work unit code/work center combination. Nevertheless, because of this variation and the widely questioned validity of data in AFM 66-1,

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*Department of the Air Force, *Maintenance Management*, AFM 66-1, Volume I, July 1, 1978.

Table 5

DISTRIBUTION FACTORS RELATING WORK UNIT CODE CATEGORIES TO LCOM WORK CENTER GROUPS

Work Unit Code Digits	Work Unit Code Categories	Percent of Work Unit Code Hours Allocated to Each LCOM Work Center Group			
		Flight Line and Inspection	Aerospace Systems and Structural Repair	Jet Engine Shop	Avionics
0	Aircraft Support General	46.8	27.8	9.4	16.0
1	Air Frame, Landing Gear, and Flight Controls	28.9	65.8	.2	5.1
2	Propulsion System	3.5	7.0	86.0	3.5
3,4	Aerospace Systems	13.6	68.4	2.7	15.3
5	Instruments and Autopilot	6.9	5.9	3.1	84.1
6,7	Communication, Navigation, and Mission Systems	5.3	4.2	-0-	90.5
8,9	TOW Target Equipment and Personnel Equipment	8.4	69.4	.8	21.4

SOURCE: Derived from AFM 66-1 data tapes from the following Air Force bases: F-4C, D, and E, George (1970); F-111D, Cannon (1976); F-111A, Nellis (1976); A-7D, England (1976); F-106, McChord (1973-1975); F-15, Luke (1975); and RF-4C, Holloman (1975-1976).

sensitivity analysis of the MMH/S for the work unit code categories has not been incorporated in MANPOWER.

The total MMH/S in any work center group (i) is equal to the sum of the products of the percentage (P) of work in work unit code category (j) for that work center group (i) and the MMH/S in that work unit code category (j). This is abbreviated:

$$MMH/S_i = \sum_{j=1}^{7} P_{ij}(MMH/S_j).$$

3. MTBF, MTTR, and MMH/S in general support. The user can input the MTBF and MTTR for 37 second-digit work unit codes and MMH/S for general support (work unit code = 0). MMH/S are

calculated at the second-digit level (k) by the following formula:

$$MMH/S_k = (1/(MTBF_k/\text{sortie length}))(MTTR_k).$$

The second-digit MMH/S are aggregated to the first-digit work unit code level and distributed among the four work center groups using the factors described above (shown in Table 5). The 37 second-digit work unit code categories are listed in the Appendix and are also shown in the sample output in Sec. III.

4. MTBF, MTTR, MMH/S in general support, and distribution factors for each second-digit work unit code and general support. The distribution factors are used to allocate the workload for each of the 37 second-digit work unit codes and general support *directly* to the four work center groups. MMH/S in work center group (i) is calculated as follows:

$$MMH/S_i = \sum_{j=1}^{38} P_{ij}(MMH/S_j),$$

where P_{ij} is the percentage of work in second-digit work unit code category (j) (or in general support) that is done in work center group (i); and MMH/S_j is the calculated MMH/S in second-digit work unit code category (j). MMH/S_j equals $(1/(MTBF_j/\text{sortie length}))$ $(MTTR_j)$, as before.

Peacetime Requirements Versus Wartime Requirements

The manning of an aircraft maintenance shop must be sufficient to meet both peacetime and wartime maintenance requirements. For work centers with different requirements in the two environments, MANPOWER calculates both and allocates the larger.

Not all work centers have both peacetime and wartime standards. Some have only wartime standards and these are assumed to provide sufficient manning for peacetime operations. For example, the LCOM work center requirements are based on expected maintenance demands in a wartime scenario; peacetime simulations have not yet been run. Figures 1-5 indicate which work centers have separately calculated peacetime requirements.

MANPOWER maintains running totals of the peacetime and wartime requirements as it processes each shop and prints out a comparison of the total requirements in each environment. In "standard manned" work centers that have only one requirement, the peacetime and wartime values are assumed to be the same and the single value is added to both totals.

A gross approximation of the peacetime requirement in the LCOM shops is calculated by adjusting wartime manning for the differences in peacetime flying hours and peacetime personnel availability. The following formula yields peacetime manning:

$$\frac{\text{peacetime total workload}}{\text{wartime total workload}} \times \text{wartime manning} \times 1.68$$

Since the total maintenance workload in MANPOWER is a function of flying hours, this formula adjusts the wartime manning to reflect the lower flying rate in peacetime.* Also, since personnel are available 144 hours per month during peace compared with 242 hours per month in war, 1.68 peacetime mechanics are needed to do the work of one mechanic in wartime.†

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*MANPOWER assumes 22 flying days per month during peacetime and 30 flying days in wartime.

†This procedure is similar to the one TAC analysts employ in adjusting the results of an LCOM simulation run. In these runs, the analysts assume personnel are available for 12 hour shifts, seven days per week (30.44 days/month x 12 hr/day = 365.28 hr/month). To reflect the standard wartime availability assumption of 242 hr/month, the LCOM manning must be multiplied by 1.51 (365.28 ÷ 242 = 1.51) to yield the required manning in war.

Wartime Deployment and Minimum Manning

An important factor in the model is the pattern of wartime deployment of aircraft wings and squadrons. Aircraft stationed at one base during peace may be deployed to one, two, or more separate locations during war. Each deployment (consisting of one or more squadrons) must be provided separate capability to carry out the maintenance necessary for the accomplishment of its mission. Therefore, the total wartime requirement for a peacetime base is equal to the sum of the requirements for each of the deployable units. For example, a work center serving 48 aircraft (two squadrons of 24 UE) might require minimum manning of two per shift for three shifts (a total of six personnel). If these two squadrons are to be deployed separately in war, then a minimum of 12 mechanics would be required (six for each squadron). MANPOWER insures that each deployment is provided at least minimum contingency manning in each work center.

MANPOWER has the capability to generate manning for up to four squadrons deployed four ways. The deployment pattern can have a significant impact on manning because there are often economies of scale associated with the deployment of multiple squadrons to a single location. For example, three squadrons deployed three ways may require 45 mechanics in a shop, three squadrons two ways, 36 mechanics, and three squadrons one way, only 30 mechanics. When these differences are taken into account for all shops and the entire fleet of aircraft, the impact of alternative deployment patterns on total manning is usually significant.

Manning for the following deployment patterns is calculated in MANPOWER:

Base Size (No. of Squadrons at Base)	Possible Deployment Patterns	Number of Squadrons in Each Deploying Unit
1	One-way	1
2	One-way	2
	Two-ways	1-1
3	One-way	3
	Two-ways	2-1
	Three-ways	1-1-1
4	One-way[a]	4
	Two-ways	2-2
	Two-ways	3-1
	Three-ways	2-1-1
	Four-ways	1-1-1-1

[a]The Tactical Air Command normally does not determine requirements for four squadrons deploying one-way. Simple linear extrapolation of the one, two, and three squadron cases was used to estimate this requirement.

Rounding Fractional Requirements

All rounding of manpower allocations is according to Air Force procedures. Table 6 shows the minimum fraction required to warrant rounding upward.

Linear Interpolation

Tactical Air Command guidelines allocate overhead and supervisory personnel according to the UE deployed (see the technical appendix, Vol. II). When the user inputs a "nonstandard" deployment size (e.g., 22 or 33) MANPOWER linearly interpolates to determine the manpower requirement.

Integrated Versus Nonintegrated Avionics

MANPOWER uses different equations for aircraft with "integrated" and "nonintegrated avionics" to calculate the requirements in the Avionics Maintenance shops. Two equations have been adopted because

Table 6

CRITERIA FOR ROUNDING IN MANPOWER COMPUTATIONS

Fractional Manpower	Authorized Manpower
1.077 or greater	2
2.154 " "	3
3.231 " "	4
4.308 " "	5
5.385 " "	6
6.462 " "	7
7.539 " "	8
8.616 " "	9
9.693 " "	10
10.770 " "	11
11.847 " "	12
12.924 " "	13
13.999 " "	14

SOURCE: *Simulating Maintenance Manning for New Weapon Systems: Building and Operating A Simulation Model*, AFHRL-TR-74-97 (II), Air Force Human Resources Laboratory, Air Force Systems Command, Brooks Air Force Base, Texas, December 1974, p. 125.

the analysis indicated a significantly different utilization rate* for the two types of avionics (see the technical appendix, Vol. II). The utilization rate in shops that maintain the newer, "integrated" avionics is significantly lower than that in shops that maintain the more traditional avionics.

In determining whether the prospective aircraft is to be considered as having integrated avionics, the following points should be kept in mind. The existence of integrated avionics is a matter of degree; one should speak of more or less integration, rather than of integrated or not integrated. The greater the integration, the greater the communication between functional components and between components and the crew by means of a digital computer complex. Also,

*The utilization rate is the percentage of available hours a person is actually engaged in simulated tasks. A rate of 60 percent is high; one of 20 percent is low.

the greater the integration, the greater the knowledge one must have of how the total system output is affected by a subsystem failure (in order to repair the system).

If the prospective aircraft avionics are more like those of the F-111D and F-16 than those of the F-4E, A-7D, A-10, and RF-4C, then the user should designate the new system as having integrated avionics. The F-111D and F-16 have digital computers and employ automatic test stations that *simulate* the operation of the entire avionics system. This complex test equipment is not required to maintain the avionics of the A-7D, A-10, and F-4.

To reflect the frequent changes now occurring in the organization of Avionics Maintenance, the user must input the number of shops in the Avionics Squadron. The more traditional avionics organizations will have seven or eight shops; newer systems may have only four or five.

III. GENERAL INSTRUCTIONS FOR INPUT AND ILLUSTRATIVE CASE

In the following pages we discuss input options using an illustrative case as a vehicle. The Appendix contains input format statements and lists the codes for each variable.

MODEL INPUTS

The complete input deck for the example output report shown in this section is presented in Table 7. User choices will be considered card by card.

Card 1.01

Aircraft type can be fighter, attack, or reconnaissance. Currently, the model differentiates only between reconnaissance and all other types in determining requirements. Reconnaissance aircraft have slightly different needs in AGE and Munitions Maintenance. Additional improvements in MANPOWER most likely will require distinguishing between all three mission types.

Card 2.01

The *detailed output option* prints out the personnel requirement for LCOM shops, standard manned shops, and overhead and supervision within each of the five principal subdivisions of the maintenance organization for each deployment pattern selected by the user. When this print is not desired, the user inputs 0 and receives only the total requirement for each of the five divisions for each deployment pattern. In our sample case, the detailed deployment manning is printed following the squadron level summary for each deployment pattern.

Card 3.01

Two items of information are required on the *avionics indicator* card: First, the user must indicate whether the prospective aircraft will have traditional "nonintegrated" avionics or the more advanced

Table 7

INPUT DATA FOR ILLUSTRATIVE CASE

Card No.	Input Data[a]
1.01	FIGHTER
2.01	1
3.01	1 5
4.01	3
5.01	18.23 15.97 .60 .20 .10 .10
to 5.37	(Thirty-seven cards with identical format; see Table 8, Part III.A, for input data list.)
5.38	10.52 3 .72 .13 .10 .05
5.39	223.53 13.59 .48 .12 .28 .12
5.40	24.54 4.58 .49 .11 .29 .11
5.41	25.55 5.57 .50 .10 .30 .10
6.01	24 7
7.01	.75 1.06
8.01	1.5 1.8
9.01	.3
10.01 to 25.01	(These inputs are fixed parameters of MANPOWER.)
26.01	3 4 4 5 5 5 6 6 6 6 7 7 8
27.01	6 8 10
28.01	6.2 6.2
29.01	7.9 7.9
30.01	6 8 10
31.01	4
32.01	1-1 6 1.0 1.0
32.02	2-1 9 2.0 2.0
32.03	3-2 8 3.0 2.0 1.0
32.04	3-1 7 3.0 3.0
33.01	7
34.01	1 3.0 15.0 3.0
34.02	2 2.0 5.0 .5
34.03	3 1.0 7.0 1.0
34.04	4 1.0 7.0 1.0
34.05	5 .5 2.5 .4
34.06	6 .6 1.0 .1
34.07	7 .6 1.2 .1

[a]Exact column positions are given in the Appendix.

"integrated" type; and second, the model must be told the number of shops in Avionics Maintenance. These variables have been discussed in Sec. II. In the illustration, the aircraft is assumed to have five avionics work centers maintaining advanced equipment.

Card 4.01

This item indicates the form of the maintenance workload input. Called the *maintenance hours indicator*, it has the following possible values:

Value	Meaning
0	MMH/FH in four work center groups will be input.
1	MMH/S in seven work unit code categories will be input.
2	MTBF and MTTR in 37 (or more) second-digit work unit code categories and MMH/S for general support will be input.
3	MTBF, MTTR, and distribution factors for 37 (or more) second-digit work unit code categories and MMH/S for general support will be input.

In the example, the last, and most complex, input format has been chosen.

Cards 5.01 to 5.41

These cards contain the maintenance workload assumptions. The specific requirements of each format (0-3) are given in the Appendix. Whichever format is used, the workload estimate should include the time to perform the following tasks:

- o Troubleshooting
- o Obtaining access
- o Jacking
- o Getting and hooking up support equipment
- o Removing and replacing components
- o Inspecting
- o Repairing on-aircraft
- o Verifying system works
- o Aircraft handling and towing

- o Loading and downloading
- o Checking and repairing components
- o Disassembling and assembling

Tasks that should not be included are supervision, administration, meeting, training, shop equipment maintenance, record keeping, clean-up, and equipment modifications.

In the early stages of system acquisition, maintenance manhours, MTTR, and MTBF are usually specified as goals. These should be based on the performance of similar aircraft currently in the operational inventory. Expected improvements in the state of the art in reliability and maintainability should be incorporated in the new aircraft goals.

The following comments address the alternative input variables.

- o MMH/FH should be for each of the four work center groups defined in Sec. II (the card positions are given in the Appendix). Work performed in other work centers should not be included. (These other work centers are listed in Table 2.)
- o MMH/S in the seven work unit code categories should include only work done in the work centers included in the four groups. For example, general support tasks that are performed by Corrosion Control or the Machine Shop should not be included.
- o MTTR. Again, the only relevant work is that done in the LCOM shops included in the four work center groups. This value should equal the *average total manhours* per repair action for all types of actions.
- o MTBF. This should be the *average flying hours* between repair actions. In real operations, an actual failure does not have to occur to produce repair actions. MTTR and MTBF estimates should include "false alarms" and other "unsuccessful" repair actions.
- o The *distribution factors* (input mode = 3) indicate how the total maintenance manhours in each of the second-digit work unit code categories should be distributed among the four work center groups. The Appendix contains sets of these factors

derived for selected aircraft. The user can employ these factors or modify them according to his best information.

As can be seen in Table 7, the sample input is according to mode 3 and includes 37 sets of MTBF, MTTR, and four distribution factors. It also includes (Card 5.38) an estimate of MMH/S in general support (first field) and four distribution factors for this estimate. In addition, the user has said there are three new systems in this aircraft (indicated by the integer in the second field of Card 5.38) and has supplied the standard MTBF, MTTR, and four distribution factors for these systems (Cards 5.39 to 5.41). The names of the 37 work unit code categories and their respective input values are shown in Table 8, Part III.

Card 6.01

Aircraft per squadron in the example is the standard 24. The impact of squadron size on personnel requirements can be explored by varying this variable. Traditionally, reconnaissance aircraft have been grouped in squadrons of 18, whereas fighter and attack aircraft have been massed in contingents of 24. However, occasionally fighter squadrons contain 28 UE. The more aircraft per squadron, the lower the fixed personnel requirement per aircraft; hence, the larger the squadrons, the lower the total personnel requirement.

This card also indicates the number of "alert" aircraft per squadron; in the example, there are seven. Each alert aircraft requires one additional crew chief in Organizational Maintenance.

Card 7.01

Sortie rates during peacetime and wartime (respectively) are contained on this card. The sortie rate is the average number of sorties per aircraft per flying day (30 days during war and 22 days during peace). The wartime sortie rate for the sustained mission is usually higher than the peacetime rate. It varies by aircraft type: lowest for reconnaissance and highest for fighters. High sortie rates are 1.2 and 1.3 and low sortie rates are .6 and .7.

Card 8.01

Sortie length is expressed in hours. In the example, the mean peacetime length is 1.5 and the mean wartime length is 1.8. Sorties usually average between 1 and 3 hours.

Card 9.01

The number of *air superiority missions* has a small effect on the Munitions Maintenance manpower requirement. Thirty and forty percent of sorties are representative values.

Cards 10.01 to 25.01

These inputs are fixed parameters of MANPOWER.

Cards 26.01 to 30.01

These cards contain constant factors in the manning equations for AGE.

Card 31.01

Integer (4 in the example) indicates the number of different deployment patterns that are described in the following cards.

Cards 32.01 to 32.04

One card is submitted for each deployment pattern. It describes the deployment pattern, the number of squadrons, and the number of bases of this type. The requirements of these cards are adequately described in the Appendix.

In the example, there are six bases with one squadron deployed one way, nine bases with two squadrons deployed one way, eight bases with three squadrons deployed two ways, and seven bases with three squadrons deployed one way.

Card 33.01

Integer (7 in the example) that indicates the number of different sensitivity analyses to be conducted. The cards that follow contain the parameters for each sensitivity analysis.

Cards 34.01 to 34.07

One card is submitted for each type of sensitivity analysis desired by the user. The card requires: (a) a code indicating the kind of sensitivity analysis, (b) a low sensitivity value, (c) a high sensitivity value, and (d) a sensitivity increment. In the example, the following sensitivity analyses are to be conducted.

Code	Type of Analysis
1,2,3,4	The sensitivity variables are MMH/FH in the four work center groups. Organizational MMH/FH will range from 3.0 to 15.0 in increments of 3.0; Jet Engine Shop MMH/FH will range from 2.0 to 5.0 in increments of .5; and Field and Avionics MMH/FH will range from 1.0 to 7.0 in increments of 1.0.
5	The sensitivity variable is the total MMH/FH or MMH/S in all four work center groups. The high and low sensitivity values are input as *percentages* of the *base case*. In our illustration, the MMH/S value in the LCOM equations will range from 50 percent to 250 percent of the base case value. For example, the base case for Organizational Maintenance is 13.4 MMH/S (see Part III, B.1 of Table 8); in the sensitivity analysis, this variable will assume values from 6.7 MMH/S to 33.5 MMH/S.
6,7	The sensitivity variables are the peacetime and wartime sortie rates. In the illustration, the peacetime rate will vary from .6 to 1.0 in increments of .1 and the wartime rate will range from .6 to 1.2 with the same increment.

MODEL OUTPUT

The MANPOWER report is organized in six parts:

I Fleet Description

II Operational Assumptions

III Maintenance Assumptions

IV Fleet Manpower Requirements

V Deployment Pattern Manpower Requirements

VI Sensitivity Analysis

Parts I-IV are illustrated in Table 8, Part V is shown in Table 9, and the sensitivity analysis is presented in Table 10.

The fleet description summarizes user input deployment patterns, squadron size, and aircraft features. The total number of aircraft in our illustration is 1656; they are stationed at 30 bases and deploy in four different patterns.

Operational assumptions are the sortie rates (wartime and peacetime), sortie lengths, and air superiority missions. Calculated average flying hours per aircraft per month in our example are 24.75 hours in peacetime and 57.24 hours in wartime.

The maintenance assumptions section displays, first, user input maintenance workload estimates. In the example, MTBF, MTTR, and the workload distribution factors are illustrated. Also printed in this section of the report are the calculated MMH/S in the four work center groups used in the LCOM manning equations. Based on the reliability and maintainability inputs in our example, there are 13.4 MMH/S in Organizational Maintenance, 7.5 MMH/S in Field Maintenance, 6.9 MMH/S in the Jet Engine Shop, and 10.2 MMH/S in Avionics Maintenance.

The fleet manpower requirements section summarizes total fleet requirements for both LCOM and nonsimulated shops. Part B of fleet manpower requirements recaps the principal assumptions underlying the estimate of total personnel requirements. Following this, officers and enlisted personnel are broken out. The final comparison at the fleet level is between peacetime and wartime requirements.

Deployment pattern personnel requirements at the maintenance squadron level are shown in Table 9 for each pattern in the analysis. In addition, because the detailed deployment manning option has been selected in our example, requirements are shown for LCOM shops, standard manned shops, and overhead and supervision within each deployment pattern. Another model feature illustrated here is the

Table 8

NEW TACTICAL AIRCRAFT MAINTENANCE PERSONNEL REQUIREMENTS

I. FLEET DESCRIPTION

A. AIRCRAFT TYPE FIGHTER
B. AVIONICS TYPE INTEGRATED (5 SHOPS)
C. FLEET SIZE 1656
D. AIRCRAFT PER SQUADRON 24
E. ALERT AIRCRAFT PER SQUADRON 7
F. FLEET BASING AND DEPLOYMENT:

BASE SIZE (NUMBER OF SQUADRONS AT BASE)	DEPLOYMENT PATTERN	NUMBER OF BASES IN THE ANALYSIS
1		
	ONE-WAY	6
2		
	ONE-WAY	9
	TWO-WAYS	0
3		
	ONE-WAY	7
	TWO-WAYS	8
	THREE-WAYS	0
4		
	ONE-WAY	0
	TWO-WAYS (2-2)	0
	TWO-WAYS (3-1)	0
	THREE-WAYS	0
	FOUR-WAYS	0

II. OPERATIONAL ASSUMPTIONS

A.	SORTIE RATE (SORTIES/AIRCRAFT/DAY):	PEACETIME	0.75
		WARTIME	1.06
B.	MEAN SORTIE LENGTH (HOURS):	PEACETIME	1.50
		WARTIME	1.80
C.	TOTAL FLYING HOURS/AIRCRAFT/MONTH:	PEACETIME	24.75
		WARTIME	57.24
D.	AIR SUPERIORITY MISSIONS (PERCENT OF SORTIES)		30.00

III. MAINTENANCE ASSUMPTIONS

A. USER INPUT MAINTENANCE MANHOUR REQUIREMENTS

TWO DIGIT WORK UNIT CODE	SYSTEM NAME	MEAN TIME BETWEEN FAILURES (FLYING HRS)	MEAN TIME TO REPAIR (HOURS)
11	AIR FRAME	18.2	16.0
12	COCKPIT & FUSELAGE COMPARTMENTS	28.2	17.0
13	LANDING GEAR SYSTEM	32.5	17.9
14	FLIGHT CONTROLS	44.6	18.9
16	ESCAPE CAPSULE	251.0	19.9
23	POWER PLANT	96.0	199.9
24	SECONDARY POWER SYSTEM	173.0	81.9
41	ENVIRONMENTAL CONTROL SYSTEM	84.0	12.9
42	ELECTRICAL SYSTEM	95.0	13.9
44	LIGHTING SYSTEM	76.1	14.9
45	HYDRAULIC SYSTEM	77.1	15.9
46	FUEL SYSTEM	121.1	16.9
47	OXYGEN SYSTEM	12.1	9.8

Table 8 (Cont.)

49	MISCELLANEOUS UTILITIES	13.1	8.8
51	INSTRUMENTS	14.1	7.8
52	AUTO PILOT	15.1	6.8
55	MALFUNCTION ANALYSIS EQUIPMENT	16.1	5.8
57	GUIDANCE & FLIGHT CONTROL SYSTEM	17.1	4.8
61	HF COMMUNICATIONS	18.1	3.8
62	VHF COMMUNICATIONS	19.2	2.8
63	UHF COMMUNICATIONS	10.2	5.8
64	INTERPHONE	11.2	6.8
65	IFF SYSTEM	12.2	7.8
69A	COMMUNICATION & NAVIGATION PACKA	13.2	8.7
69B	MISC. COMMUNICATIONS EQUIPMENT	14.2	9.7
71	RADIO NAVIGATION	15.2	0.7
72	RADAR NAVIGATION	16.2	1.7
73	BOMBING NAVIGATION	17.2	2.7
74	FIRE CONTROL SYSTEM	18.3	3.7
75	WEAPONS DELIVERY SYSTEM	19.3	4.7
76	ELECTRONIC COUNTERMEASURES	20.3	5.7
77	PHOTO/RECONNAISSANCE	21.3	6.7
91	EMERGENCY EQUIPMENT	22.3	7.6
92	TOW TARGET EQUIPMENT	23.3	8.6
93	DRAG CHUTE EQUIPMENT	224.3	9.6
96	PERSONNEL & MISC. EQUIPMENT	25.3	0.6
97	EXPLOSIVE DEVICES	21.5	1.6
XX	NEW SYSTEM # 1	223.5	13.6
XX	NEW SYSTEM # 2	24.5	4.6
XX	NEW SYSTEM # 3	25.5	5.6
00	GENERAL SUPPORT MANHOURS PER SORTIE =	10.5	

A.1 USER INPUT WORKLOAD DISTRIBUTION FACTORS

TWO DIGIT WORK UNIT CODE	SYSTEM NAME	PERCENT OF WORKLOAD ALLOCATED TO EACH LCOM WORK CENTER GROUP FLIGHT LINE	AEROSPACE SYSTEMS	JET ENGINE	AVION-ICS
11	AIR FRAME	0.60	0.20	0.10	0.10
12	COCKPIT & FUSELAGE	0.49	0.21	0.11	0.19
13	LANDING GEAR SYSTEM	0.38	0.42	0.12	0.08
14	FLIGHT CONTROLS	0.17	0.43	0.13	0.27
16	ESCAPE CAPSULE	0.46	0.34	0.14	0.06
23	POWER PLANT	0.10	0.05	0.83	0.02
24	SECONDARY POWER SYSTEM	0.14	0.06	0.76	0.04
41	ENVIRONMENTAL CONTROL SYSTEM	0.33	0.57	0.07	0.03
42	ELECTRICAL SYSTEM	0.12	0.78	0.02	0.08
44	LIGHTING SYSTEM	0.11	0.69	0.09	0.11
45	HYDRAULIC SYSTEM	0.20	0.60	0.20	0.00
46	FUEL SYSTEM	0.19	0.61	0.11	0.09
47	OXYGEN SYSTEM	0.14	0.72	0.12	0.02
49	MISCELLANEOUS UTILITIES	0.07	0.33	0.23	0.37
51	INSTRUMENTS	0.06	0.04	0.04	0.86
52	AUTO PILOT	0.05	0.05	0.05	0.85
55	MALFUNCTION ANALYSIS EQUIP	0.04	0.16	0.00	0.80
57	GUIDANCE & FLIGHT CONTROL	0.03	0.07	0.07	0.83
61	HF COMMUNICATIONS	0.12	0.18	0.00	0.70
62	VHF COMMUNICATIONS	0.11	0.09	0.09	0.71
63	UHF COMMUNICATIONS	0.10	0.30	0.30	0.30
64	INTERPHONE	0.11	0.09	0.01	0.79
65	IFF SYSTEM	0.12	0.08	0.02	0.78
69A	COMMUNICATION & NAVIGATION	0.13	0.07	0.03	0.77
69B	MISC. COMMUNICATIONS EQUIP	0.14	0.06	0.04	0.76
71	RADIO NAVIGATION	0.15	0.05	0.05	0.75
72	RADAR NAVIGATION	0.36	0.04	0.06	0.54

Table 8 (Cont.)

73	BOMBING NAVIGATION	0.37	0.23	0.00	0.40
74	FIRE CONTROL SYSTEM	0.38	0.32	0.08	0.22
75	WEAPONS DELIVERY SYSTEM	0.39	0.20	0.00	0.41
76	ELECTRONIC COUNTERMEASURES	0.10	0.20	0.05	0.65
77	PHOTO/RECONNAISSANCE	0.11	0.09	0.01	0.79
91	EMERGENCY EQUIPMENT	0.42	0.48	0.02	0.08
92	TOW TARGET EQUIPMENT	0.60	0.37	0.03	0.00
93	DRAG CHUTE EQUIPMENT	0.64	0.26	0.04	0.06
96	PERSONNEL & MISC. EQUIPMENT	0.45	0.35	0.05	0.15
97	EXPLOSIVE DEVICES	0.22	0.74	0.00	0.04
XX	NEW SYSTEM # 1	0.48	0.12	0.28	0.12
XX	NEW SYSTEM # 2	0.49	0.11	0.29	0.11
XX	NEW SYSTEM # 3	0.50	0.10	0.30	0.10
00	GENERAL SUPPORT	0.72	0.13	0.10	0.05

B. CALCULATED MAINTENANCE MANHOURS PER SORTIE USED IN LCOM SHOP EQUATIONS

1. MAINTENANCE MANHOURS PER SORTIE FOR ORGANIZATIONAL MAINTENANCE = 13.4
2. MAINTENANCE MANHOURS PER SORTIE FOR AEROSPACE SYSTEMS, STRUCTURAL REPAIR,AND REPAIR & RECLAMATION = 7.5
3. MAINTENANCE MANHOURS PER SORTIE FOR JET ENGINE MAINTENANCE = 6.9
4. MAINTENANCE MANHOURS PER SORTIE FOR AVIONICS MAINTENANCE = 10.2
5. TOTAL DIRECT MAINTENANCE MANHOURS PER SORTIE = 38.0

IV. FLEET MANPOWER REQUIREMENTS

A. TOTAL FLEET REQUIREMENTS

TOTAL LCOM SHOP REQUIREMENTS	16531
TOTAL NON LCOM SHOP REQUIREMENTS	21703
TOTAL FLEET MANPOWER REQUIREMENTS	38234

B. PRINCIPAL ASSUMPTIONS UNDERLYING THESE ESTIMATES

TOTAL AIRCRAFT	1656
NUMBER OF BASES	30
FLYING HOURS/AIRCRAFT/MONTH	
PEACETIME	24.75
WARTIME	57.24
SORTIE RATE PEACETIME	0.75
SORTIE RATE WARTIME	1.06
TOTAL MAINTENANCE MANHOURS/FLYING HOUR	21.09

C. OFFICERS VERSUS ENLISTED

OFFICERS	897
ENLISTED	37337
TOTAL FLEET	38234

D. WARTIME VERSUS PEACETIME REQUIREMENTS

PEACETIME VERSUS WARTIME REQUIREMENTS FOR LCOM SIMULATED SHOPS:

WARTIME REQUIREMENTS	16531
PEACETIME REQUIREMENTS	11997
DIFFERENCE	4534

PEACETIME VERSUS WARTIME REQUIREMENTS FOR NON-SIMULATED SHOPS:

WARTIME REQUIREMENTS	21331
PEACETIME REQUIREMENTS	20476
DIFFERENCE	855

Table 9

MANNING BY DEPLOYMENT PATTERN

V. DEPLOYMENT PATTERN MANPOWER REQUIREMENTS

DEPLOYMENT: 1 SQUADRON, ONE-WAY

MAINTENANCE SQUADRON	NUMBER OF PERSONNEL	OFFICERS	ENLISTED
CHIEF OF MAINTENANCE	90	5	85
ORGANIZATIONAL	120	3	117
FIELD	201	2	199
AVIONICS	120	4	116
MUNITIONS	158	4	154
TOTAL	689	18	671

ANALYSIS OF VALUES OF INDEPENDENT VARIABLES IN THE LCOM WORK CENTER EQUATIONS:

** THE FOLLOWING EXCEPTIONS WERE NOTED **

DEPLOYMENT_SIZE: 1 SQUADRON(S)
AVIONICS MAINTENANCE
SORTIE RATE VALUE = 1.06 UPPER LIMIT = 1.0

DETAILED DEPLOYMENT MANNING

1.	CHIEF OF MAINTENANCE	90
2.	ORGANIZATIONAL MAINTENANCE:	
	A. FLIGHTLINE/INSPECTION	83
	B. OVERHEAD AND SUPERVISION	37
	TOTAL ORGANIZATIONAL	120
3.	FIELD MAINTENANCE:	
	A. LCOM SIMULATED SHOPS (EXCEPT JET ENGINE): STRUCTURAL REPAIR, REPAIR AND RECLAMATION, FUEL SYSTEMS, ELECTRICAL SYSTEMS, PNEUDRAULICS, ENVIRONMENTAL SYSTEMS, AND EGRESS SYSTEMS	74
	B. JET ENGINE	43
	C. NON-SIMULATED SHOPS: CORROSION CONTROL, SURVIVAL EQUIPMENT, NON-DESTRUCTIVE INSPECTION, MACHINE SHOP, METAL PROCESSING, AND AEROSPACE GROUND EQUIPMENT	73
	D. OVERHEAD AND SUPERVISION	11
	TOTAL FIELD	201
4.	AVIONICS MAINTENANCE:	
	A. LCOM SIMULATED SHOPS: RADIO, RADAR, DOPPLER INERTIAL NAVIGATION, INTEGRATED SYSTEM-FIRE CONTROL, AUTOMATIC FLIGHT CONTROL, INSTRUMENTS, PHOTOGRAPHIC SENSORS, WEAPON CONTROL-INERTIAL NAVIGATION,	

Table 9 (Cont.)

	COMMUNICATION-NAVIGATION-PENETRATION AIDS, AUTOMATIC TEST STATIONS, MANUAL TEST STATIONS, AVIONICS AGE, AND FLIGHTLINE AVIONICS	99
B.	NON-SIMULATED SHOPS: ECM PODS	11
C.	OVERHEAD AND SUPERVISION	10
	TOTAL AVIONICS	120
5.	MUNITIONS MAINTENANCE:	
A.	MUNITIONS SERVICES: WEAPONS LOADING, WEAPONS RELEASE, GUN SERVICES	79
B.	MUNITIONS MAINTENANCE AND STORAGE: MUNITIONS MAINTENANCE, MISSILE MAINTENANCE, STORAGE AND HANDLING, EQUIPMENT MAINTENANCE AND INSPECTION	50
C.	OVERHEAD AND SUPERVISION	29
	MUNITIONS TOTAL	158
	GRAND TOTAL	689

DEPLOYMENT: 2 SQUADRONS, ONE-WAY

MAINTENANCE SQUADRON	NUMBER OF PERSONNEL	OFFICERS	ENLISTED
CHIEF OF MAINTENANCE	107	6	101
ORGANIZATIONAL	207	5	202
FIELD	326	5	321
AVIONICS	177	5	172
MUNITIONS	289	5	284
TOTAL	1106	26	1080

ANALYSIS OF VALUES OF INDEPENDENT VARIABLES IN THE LCOM WORK CENTER EQUATIONS:

** THE FOLLOWING EXCEPTIONS WERE NOTED **

DEPLOYMENT_SIZE: 2 SQUADRON(S)
AVIONICS MAINTENANCE
SORTIE RATE VALUE = 1.06 UPPER LIMIT = 1.0

DETAILED DEPLOYMENT MANNING

1.	CHIEF OF MAINTENANCE	107
2.	ORGANIZATIONAL MAINTENANCE:	
A.	FLIGHTLINE/INSPECTION	147
B.	OVERHEAD AND SUPERVISION	60
	TOTAL ORGANIZATIONAL	207
3.	FIELD MAINTENANCE:	
A.	LCOM SIMULATED SHOPS (EXCEPT JET ENGINE): STRUCTURAL REPAIR, REPAIR AND RECLAMATION, FUEL SYSTEMS, ELECTRICAL SYSTEMS, PNEUDRAULICS, ENVIRONMENTAL SYSTEMS, AND EGRESS SYSTEMS	104
B.	JET ENGINE	78
C.	NON-SIMULATED SHOPS: CORROSION CONTROL, SURVIVAL EQUIPMENT,	

Table 9 (Cont.)

	NON-DESTRUCTIVE INSPECTION, MACHINE SHOP, METAL PROCESSING, AND AEROSPACE GROUND EQUIPMENT	129
	D. OVERHEAD AND SUPERVISION	15
	TOTAL FIELD	326
4.	AVIONICS MAINTENANCE:	
	A. LCOM SIMULATED SHOPS: RADIO, RADAR, DOPPLER INERTIAL NAVIGATION, INTEGRATED SYSTEM-FIRE CONTROL, AUTOMATIC FLIGHT CONTROL, INSTRUMENTS, PHOTOGRAPIC SENSORS, WEAPON CONTROL-INERTIAL NAVIGATION, COMMUNICATION-NAVIGATION-PENETRATION AIDS, AUTOMATIC TEST STATIONS, MANUAL TEST STATIONS, AVIONICS AGE, AND FLIGHTLINE AVIONICS	143
	B. NON-SIMULATED SHOPS: ECM PODS	21
	C. OVERHEAD AND SUPERVISION	13
	TOTAL AVIONICS	177
5.	MUNITIONS MAINTENANCE:	
	A. MUNITIONS SERVICES: WEAPONS LOADING, WEAPONS RELEASE, GUN SERVICES	158
	B. MUNITIONS MAINTENANCE AND STORAGE: MUNITIONS MAINTEN-ANCE, MISSILE MAINTENANCE, STORAGE AND HANDLING, EQUIPMENT MAINTENANCE AND INSPECTION	97
	C. OVERHEAD AND SUPERVISION	34
	MUNITIONS TOTAL	289
	GRAND TOTAL	1106

DEPLOYMENT: 3 SQUADRONS, TWO WAYS

MAINTENANCE SQUADRON	NUMBER OF PERSONNEL	OFFICERS	ENLISTED
CHIEF OF MAINTENANCE	146	11	135
ORGANIZATIONAL	328	8	320
FIELD	519	7	512
AVIONICS	297	9	288
MUNITIONS	421	9	412
TOTAL	1711	44	1667

ANALYSIS OF VALUES OF INDEPENDENT VARIABLES IN THE LCOM WORK CENTER EQUATIONS:

** THE FOLLOWING EXCEPTIONS WERE NOTED **

DEPLOYMENT_SIZE: 2 SQUADRON(S)
AVIONICS MAINTENANCE
SORTIE RATE VALUE = 1.06 UPPER LIMIT = 1.0
DEPLOYMENT_SIZE: 1 SQUADRON(S)
AVIONICS MAINTENANCE
SORTIE RATE VALUE = 1.06 UPPER LIMIT = 1.0

DETAILED DEPLOYMENT MANNING

1.	CHIEF OF MAINTENANCE	146

Table 9 (Cont.)

2. ORGANIZATIONAL MAINTENANCE:	
A. FLIGHTLINE/INSPECTION	231
B. OVERHEAD AND SUPERVISION	97
TOTAL ORGANIZATIONAL	328
3. FIELD MAINTENANCE:	
A. LCOM SIMULATED SHOPS (EXCEPT JET ENGINE): STRUCTURAL REPAIR, REPAIR AND RECLAMATION, FUEL SYSTEMS, ELECTRICAL SYSTEMS, PNEUDRAULICS, ENVIRONMENTAL SYSTEMS, AND EGRESS SYSTEMS	178
B. JET ENGINE	121
C. NON-SIMULATED SHOPS: CORROSION CONTROL, SURVIVAL EQUIPMENT, NON-DESTRUCTIVE INSPECTION, MACHINE SHOP, METAL PROCESSING, AND AEROSPACE GROUND EQUIPMENT	194
D. OVERHEAD AND SUPERVISION	26
TOTAL FIELD	519
4. AVIONICS MAINTENANCE:	
A. LCOM SIMULATED SHOPS: RADIO, RADAR, DOPPLER INERTIAL NAVIGATION, INTEGRATED SYSTEM-FIRE CONTROL, AUTOMATIC FLIGHT CONTROL, INSTRUMENTS, PHOTOGRAPIC SENSORS, WEAPON CONTROL-INERTIAL NAVIGATION, COMMUNICATION-NAVIGATION-PENETRATION AIDS, AUTOMATIC TEST STATIONS, MANUAL TEST STATIONS, AVIONICS AGE, AND FLIGHTLINE AVIONICS	243
B. NON-SIMULATED SHOPS: ECM PODS	31
C. OVERHEAD AND SUPERVISION	23
TOTAL AVIONICS	297
5. MUNITIONS MAINTENANCE:	
A. MUNITIONS SERVICES: WEAPONS LOADING, WEAPONS RELEASE, GUN SERVICES	237
B. MUNITIONS MAINTENANCE AND STORAGE: MUNITIONS MAINTENANCE, MISSILE MAINTENANCE, STORAGE AND HANDLING, EQUIPMENT MAINTENANCE AND INSPECTION	145
C. OVERHEAD AND SUPERVISION	39
MUNITIONS TOTAL	421
GRAND TOTAL	1711

DEPLOYMENT: 3 SQUADRONS, ONE WAY

MAINTENANCE SQUADRON	NUMBER OF PERSONNEL	OFFICERS	ENLISTED
CHIEF OF MAINTENANCE	131	7	124
ORGANIZATIONAL	286	6	280
FIELD	435	5	430
AVIONICS	221	5	216
MUNITIONS	421	6	415
TOTAL	1494	29	1465

Table 9 (Cont.)

ANALYSIS OF VALUES OF INDEPENDENT VARIABLES IN THE LCOM WORK CENTER EQUATINS:

** THE FOLLOWING EXCEPTIONS WERE NOTED **

DEPLOYMENT_SIZE: 3 SQUADRON(S)
AVIONICS MAINTENANCE
SORTIE RATE VALUE = 1.06 UPPER LIMIT = 1.0

DETAILED DEPLOYMENT MANNING

1.	CHIEF OF MAINTENANCE	131
2.	ORGANIZATIONAL MAINTENANCE:	
	A. FLIGHTLINE/INSPECTION	204
	B. OVERHEAD AND SUPERVISION	82
	TOTAL ORGANIZATIONAL	286
3.	FIELD MAINTENANCE:	
	A. LCOM SIMULATED SHOPS (EXCEPT JET ENGINE): STRUCTURAL REPAIR, REPAIR AND RECLAMATION, FUEL SYSTEMS, ELECTRICAL SYSTEMS, PNEUDRAULICS, ENVIRONMENTAL SYSTEMS, AND EGRESS SYSTEMS	126
	B. JET ENGINE	109
	C. NON-SIMULATED SHOPS: CORROSION CONTROL, SURVIVAL EQUIPMENT, NON-DESTRUCTIVE INSPECTION, MACHINE SHOP, METAL PROCESSING, AND AEROSPACE GROUND EQUIPMENT	182
	D. OVERHEAD AND SUPERVISION	18
	TOTAL FIELD	435
4.	AVIONICS MAINTENANCE:	
	A. LCOM SIMULATED SHOPS: RADIO, RADAR, DOPPLER INERTIAL NAVIGATION, INTEGRATED SYSTEM-FIRE CONTROL, AUTOMATIC FLIGHT CONTROL, INSTRUMENTS, PHOTOGRAPIC SENSORS, WEAPON CONTROL-INERTIAL NAVIGATION, COMMUNICATION-NAVIGATION-PENETRATION AIDS, AUTOMATIC TEST STATIONS, MANUAL TEST STATIONS, AVIONICS AGE, AND FLIGHTLINE AVIONICS	176
	B. NON-SIMULATED SHOPS: ECM PODS	31
	C. OVERHEAD AND SUPERVISION	14
	TOTAL AVIONICS	221
5.	MUNITIONS MAINTENANCE:	
	A. MUNITIONS SERVICES: WEAPONS LOADING, WEAPONS RELEASE, GUN SERVICES	237
	B. MUNITIONS MAINTENANCE AND STORAGE: MUNITIONS MAINTENANCE, MISSILE MAINTENANCE, STORAGE AND HANDLING, EQUIPMENT MAINTENANCE AND INSPECTION	145
	C. OVERHEAD AND SUPERVISION	39
	MUNITIONS TOTAL	421
GRAND TOTAL		1494

message to indicate that the value of one of the independent variables (the wartime sortie rate for Avionics Maintenance) is outside the range of values in the data set used to derive the prediction equation (1.06 versus 1.00).

All seven types of sensitivity analysis are illustrated in Table 10. Changes in the total workload, for example, affect total fleet requirements as follows:

Change in Total MMH/FH (% of Base Case)	Total Fleet Personnel Requirement	Change in Total Fleet Personnel Requirement (% of Base Case)
- 50	32,701	-14
- 10	37,798	- 1
Base case	38,234	--
+ 30	42,257	+11
+ 70	46,356	+21
+110	50,163	+31
+150	53,812	+41

Sensitivity analysis results are reported also at the deployment pattern and maintenance squadron level as shown in the sample output.

Table 10

SENSITIVITY ANALYSIS

VI. SENSITIVITY ANALYSIS

SENSITIVITY VARIABLE = ORGANIZATIONAL MAINTENANCE MANHOURS PER FLYING HOUR

VARIABLE VALUE	3.00	6.00	9.00	12.00	15.00
TOTAL FLEET MANNING	36026	37896	39596	41198	42732
CHIEF OF MAINTENANCE	3588	3588	3588	3588	3588
ORGANIZATIONAL MAINTENANCE	5001	6871	8571	10173	11707
FIELD MAINTENANCE	11337	11337	11337	11337	11337
AVIONICS MAINTENANCE	6236	6236	6236	6236	6236
MUNITIONS MAINTENANCE	9864	9864	9864	9864	9864

1 SQUADRON, ONE-WAY

VARIABLE VALUE	3.00	6.00	9.00	12.00	15.00
TOTAL BASE MANNING	652	683	711	737	762
CHIEF OF MAINTENANCE	90	90	90	90	90
ORGANIZATIONAL MAINTENANCE	83	114	142	168	193
FIELD MAINTENANCE	201	201	201	201	201
AVIONICS MAINTENANCE	120	120	120	120	120
MUNITIONS MAINTENANCE	158	158	158	158	158

ANALYSIS OF VALUES OF INDEPENDENT VARIABLES IN THE LCOM WORK CENTER EQUATIONS:

** THE FOLLOWING EXCEPTIONS WERE NOTED **

DEPLOYMENT_SIZE: 1 SQUADRON(S)
ORGANIZATIONAL MAINTENANCE
MMH/S AT SENSITIVITY VALUE OF 3.00 = 5.40 LOWER LIMIT = 8.3
ORGANIZATIONAL MAINTENANCE
MMH/S AT SENSITIVITY VALUE OF 15.00 = 27.00 UPPER LIMIT = 25.5

2 SQUADRONS, ONE-WAY

VARIABLE VALUE	3.00	6.00	9.00	12.00	15.00
TOTAL BASE MANNING	1042	1096	1145	1191	1236
CHIEF OF MAINTENANCE	107	107	107	107	107
ORGANIZATIONAL MAINTENANCE	143	197	246	292	337
FIELD MAINTENANCE	326	326	326	326	326
AVIONICS MAINTENANCE	177	177	177	177	177
MUNITIONS MAINTENANCE	289	289	289	289	289

ANALYSIS OF VALUES OF INDEPENDENT VARIABLES IN THE LCOM WORK CENTER EQUATIONS

** THE FOLLOWING EXCEPTIONS WERE NOTED **

DEPLOYMENT_SIZE: 2 SQUADRON(S)
ORGANIZATIONAL MAINTENANCE
MMH/S AT SENSITIVITY VALUE OF 3.00 = 5.40 LOWER LIMIT = 8.3
ORGANIZATIONAL MAINTENANCE
MMH/S AT SENSITIVITY VALUE OF 15.00 = 27.00 UPPER LIMIT = 25.5

Table 10 (Cont.)

3 SQUADRONS, TWO WAYS

VARIABLE VALUE	3.00	6.00	9.00	12.00	15.00
TOTAL BASE MANNING	1610	1695	1771	1844	1913
CHIEF OF MAINTENANCE	146	146	146	146	146
ORGANIZATIONAL MAINTENANCE	227	312	388	461	530
FIELD MAINTENANCE	519	519	519	519	519
AVIONICS MAINTENANCE	297	297	297	297	297
MUNITIONS MAINTENANCE	421	421	421	421	421

ANALYSIS OF VALUES OF INDEPENDENT VARIABLES IN THE LCOM WORK CENTER EQUATIONS:

** THE FOLLOWING EXCEPTIONS WERE NOTED **

DEPLOYMENT_SIZE: 2 SQUADRON(S)
ORGANIZATIONAL MAINTENANCE
MMH/S AT SENSITIVITY VALUE OF 3.00 = 5.40 LOWER LIMIT = 8.3
ORGANIZATIONAL MAINTENANCE
MMH/S AT SENSITIVITY VALUE OF 15.00 = 27.00 UPPER LIMIT = 25.5
DEPLOYMENT_SIZE: 1 SQUADRON(S)
ORGANIZATIONAL MAINTENANCE
MMH/S AT SENSITIVITY VALUE OF 3.00 = 5.40 LOWER LIMIT = 8.3
ORGANIZATIONAL MAINTENANCE
MMH/S AT SENSITIVITY VALUE OF 15.00 = 27.00 UPPER LIMIT = 25.5

3 SQUADRONS, ONE WAY

VARIABLE VALUE	3.00	6.00	9.00	12.00	15.00
TOTAL BASE MANNING	1408	1482	1551	1615	1676
CHIEF OF MAINTENANCE	131	131	131	131	131
ORGANIZATIONAL MAINTENANCE	200	274	343	407	468
FIELD MAINTENANCE	435	435	435	435	435
AVIONICS MAINTENANCE	221	221	221	221	221
MUNITIONS MAINTENANCE	421	421	421	421	421

ANALYSIS OF VALUES OF INDEPENDENT VARIABLES IN THE LCOM WORK CENTER EQUATIONS:

** THE FOLLOWING EXCEPTIONS WERE NOTED **

DEPLOYMENT_SIZE: 3 SQUADRON(S)
ORGANIZATIONAL MAINTENANCE
MMH/S AT SENSITIVITY VALUE OF 3.00 = 5.40 LOWER LIMIT = 8.3
ORGANIZATIONAL MAINTENANCE
MMH/S AT SENSITIVITY VALUE OF 15.00 = 27.00 UPPER LIMIT = 25.5

SENSITIVITY VARIABLE = JET ENGINE MAINTENANCE MANHOURS PER FLYING HOUR

VARIABLE VALUE	2.00	2.50	3.00	3.50	4.00	4.50	5.00
TOTAL FLEET MANNING	37123	37445	37759	38049	38341	38625	38900
CHIEF OF MAINTENANCE	3588	3588	3588	3588	3588	3588	3588
ORGANIZATIONAL MAINTENANCE	7209	7209	7209	7209	7209	7209	7209
FIELD MAINTENANCE	10226	10548	10862	11152	11444	11728	12003
AVIONICS MAINTENANCE	6236	6236	6236	6236	6236	6236	6236
MUNITIONS MAINTENANCE	9864	9864	9864	9864	9864	9864	9864

1 SQUADRON, ONE-WAY

VARIABLE VALUE	2.00	2.50	3.00	3.50	4.00	4.50	5.00
TOTAL BASE MANNING	671	676	681	686	691	695	700

Table 10 (Cont.)

CHIEF OF MAINTENANCE	90	90	90	90	90	90	90
ORGANIZATIONAL MAINTENANCE	120	120	120	120	120	120	120
FIELD MAINTENANCE	183	188	193	198	203	207	212
AVIONICS MAINTENANCE	120	120	120	120	120	120	120
MUNITIONS MAINTENANCE	158	158	158	158	158	158	158
2 SQUADRONS, ONE-WAY							
VARIABLE VALUE	2.00	2.50	3.00	3.50	4.00	4.50	5.00
TOTAL BASE MANNING	1074	1083	1092	1100	1109	1117	1125
CHIEF OF MAINTENANCE	107	107	107	107	107	107	107
ORGANIZATIONAL MAINTENANCE	207	207	207	207	207	207	207
FIELD MAINTENANCE	294	303	312	320	329	337	345
AVIONICS MAINTENANCE	177	177	177	177	177	177	177
MUNITIONS MAINTENANCE	289	289	289	289	289	289	289
3 SQUADRONS, TWO WAYS							
VARIABLE VALUE	2.00	2.50	3.00	3.50	4.00	4.50	5.00
TOTAL BASE MANNING	1661	1676	1690	1703	1716	1729	1741
CHIEF OF MAINTENANCE	146	146	146	146	146	146	146
ORGANIZATIONAL MAINTENANCE	328	328	328	328	328	328	328
FIELD MAINTENANCE	469	484	498	511	524	537	549
AVIONICS MAINTENANCE	297	297	297	297	297	297	297
MUNITIONS MAINTENANCE	421	421	421	421	421	421	421
3 SQUADRONS, ONE WAY							
VARIABLE VALUE	2.00	2.50	3.00	3.50	4.00	4.50	5.00
TOTAL BASE MANNING	1449	1462	1475	1487	1498	1510	1521
CHIEF OF MAINTENANCE	131	131	131	131	131	131	131
ORGANIZATIONAL MAINTENANCE	286	286	286	286	286	286	286
FIELD MAINTENANCE	390	403	416	428	439	451	462
AVIONICS MAINTENANCE	221	221	221	221	221	221	221
MUNITIONS MAINTENANCE	421	421	421	421	421	421	421
SENSITIVITY VARIABLE = AEROSPACE SYSTEMS AND STRUCTURAL REPAIR							
VARIABLE VALUE	1.00	2.00	3.00	4.00	5.00	6.00	7.00
TOTAL FLEET MANNING	36653	37326	37915	38382	38817	39207	39559
CHIEF OF MAINTENANCE	3588	3588	3588	3588	3588	3588	3588
ORGANIZATIONAL MAINTENANCE	7209	7209	7209	7209	7209	7209	7209
FIELD MAINTENANCE	9756	10429	11018	11485	11920	12310	12662
AVIONICS MAINTENANCE	6236	6236	6236	6236	6236	6236	6236
MUNITIONS MAINTENANCE	9864	9864	9864	9864	9864	9864	9864
1 SQUADRON, ONE-WAY							
VARIABLE VALUE	1.00	2.00	3.00	4.00	5.00	6.00	7.00
TOTAL BASE MANNING	665	674	686	695	704	712	719
CHIEF OF MAINTENANCE	90	90	90	90	90	90	90
ORGANIZATIONAL MAINTENANCE	120	120	120	120	120	120	120
FIELD MAINTENANCE	177	186	198	207	216	224	231
AVIONICS MAINTENANCE	120	120	120	120	120	120	120
MUNITIONS MAINTENANCE	158	158	158	158	158	158	158
2 SQUADRONS, ONE-WAY							
VARIABLE VALUE	1.00	2.00	3.00	4.00	5.00	6.00	7.00
TOTAL BASE MANNING	1060	1081	1098	1111	1123	1134	1144
CHIEF OF MAINTENANCE	107	107	107	107	107	107	107
ORGANIZATIONAL MAINTENANCE	207	207	207	207	207	207	207
FIELD MAINTENANCE	280	301	318	331	343	354	364
AVIONICS MAINTENANCE	177	177	177	177	177	177	177

Table 10 (Cont.)

MUNITIONS MAINTENANCE	289	289	289	289	289	289	289

3 SQUADRONS, TWO WAYS

VARIABLE VALUE	1.00	2.00	3.00	4.00	5.00	6.00	7.00
TOTAL BASE MANNING	1633	1664	1692	1715	1736	1755	1772
CHIEF OF MAINTENANCE	146	146	146	146	146	146	146
ORGANIZATIONAL MAINTENANCE	328	328	328	328	328	328	328
FIELD MAINTENANCE	441	472	500	523	544	563	580
AVIONICS MAINTENANCE	297	297	297	297	297	297	297
MUNITIONS MAINTENANCE	421	421	421	421	421	421	421

3 SQUADRONS, ONE WAY

VARIABLE VALUE	1.00	2.00	3.00	4.00	5.00	6.00	7.00
TOTAL BASE MANNING	1437	1463	1483	1499	1514	1527	1539
CHIEF OF MAINTENANCE	131	131	131	131	131	131	131
ORGANIZATIONAL MAINTENANCE	286	286	286	286	286	286	286
FIELD MAINTENANCE	378	404	424	440	455	468	480
AVIONICS MAINTENANCE	221	221	221	221	221	221	221
MUNITIONS MAINTENANCE	421	421	421	421	421	421	421

SENSITIVITY VARIABLE = AVIONICS MAINTENANCE MANHOURS PER FLYING HOUR

VARIABLE VALUE	1.00	2.00	3.00	4.00	5.00	6.00	7.00
TOTAL FLEET MANNING	34883	35824	36580	37254	37858	38424	38958
CHIEF OF MAINTENANCE	3588	3588	3588	3588	3588	3588	3588
ORGANIZATIONAL MAINTENANCE	7209	7209	7209	7209	7209	7209	7209
FIELD MAINTENANCE	11337	11337	11337	11337	11337	11337	11337
AVIONICS MAINTENANCE	2885	3826	4582	5256	5860	6426	6960
MUNITIONS MAINTENANCE	9864	9864	9864	9864	9864	9864	9864

1 SQUADRON, ONE-WAY

VARIABLE VALUE	1.00	2.00	3.00	4.00	5.00	6.00	7.00
TOTAL BASE MANNING	623	642	657	670	682	693	704
CHIEF OF MAINTENANCE	90	90	90	90	90	90	90
ORGANIZATIONAL MAINTENANCE	120	120	120	120	120	120	120
FIELD MAINTENANCE	201	201	201	201	201	201	201
AVIONICS MAINTENANCE	54	73	88	101	113	124	135
MUNITIONS MAINTENANCE	158	158	158	158	158	158	158

2 SQUADRONS, ONE-WAY

VARIABLE VALUE	1.00	2.00	3.00	4.00	5.00	6.00	7.00
TOTAL BASE MANNING	1011	1038	1059	1078	1095	1111	1126
CHIEF OF MAINTENANCE	107	107	107	107	107	107	107
ORGANIZATIONAL MAINTENANCE	207	207	207	207	207	207	207
FIELD MAINTENANCE	326	326	326	326	326	326	326
AVIONICS MAINTENANCE	82	109	130	149	166	182	197
MUNITIONS MAINTENANCE	289	289	289	289	289	289	289

3 SQUADRONS, TWO WAYS

VARIABLE VALUE	1.00	2.00	3.00	4.00	5.00	6.00	7.00
TOTAL BASE MANNING	1550	1595	1631	1664	1693	1720	1745
CHIEF OF MAINTENANCE	146	146	146	146	146	146	146
ORGANIZATIONAL MAINTENANCE	328	328	328	328	328	328	328
FIELD MAINTENANCE	519	519	519	519	519	519	519
AVIONICS MAINTENANCE	136	181	217	250	279	306	331
MUNITIONS MAINTENANCE	421	421	421	421	421	421	421

3 SQUADRONS, ONE WAY

VARIABLE VALUE	1.00	2.00	3.00	4.00	5.00	6.00	7.00

Table 10 (Cont.)

TOTAL BASE MANNING	1378	1410	1437	1460	1481	1501	1520
CHIEF OF MAINTENANCE	131	131	131	131	131	131	131
ORGANIZATIONAL MAINTENANCE	286	286	286	286	286	286	286
FIELD MAINTENANCE	435	435	435	435	435	435	435
AVIONICS MAINTENANCE	105	137	164	187	208	228	247
MUNITIONS MAINTENANCE	421	421	421	421	421	421	421

SENSITIVITY VARIABLE = TOTAL MMH/FH (PERCENT OF BASE CASE)

VARIABLE VALUE	0.50	0.90	1.30	1.70	2.10	2.50
TOTAL FLEET MANNING	32701	37798	42257	46356	50163	53812
CHIEF OF MAINTENANCE	3588	3588	3588	3588	3588	3588
ORGANIZATIONAL MAINTENANCE	5469	7271	8931	10504	12005	13468
FIELD MAINTENANCE	9326	11161	12737	14170	15488	16749
AVIONICS MAINTENANCE	4454	5914	7137	8230	9218	10143
MUNITIONS MAINTENANCE	9864	9864	9864	9864	9864	9864

1 SQUADRON, ONE-WAY

VARIABLE VALUE	0.50	0.90	1.30	1.70	2.10	2.50
TOTAL BASE MANNING	592	684	765	837	904	969
CHIEF OF MAINTENANCE	90	90	90	90	90	90
ORGANIZATIONAL MAINTENANCE	91	120	148	173	198	222
FIELD MAINTENANCE	168	202	231	256	279	302
AVIONICS MAINTENANCE	85	114	138	160	179	197
MUNITIONS MAINTENANCE	158	158	158	158	158	158

ANALYSIS OF VALUES OF INDEPENDENT VARIABLES IN THE LCOM WORK CENTER EQUATIONS:

** THE FOLLOWING EXCEPTIONS WERE NOTED **

DEPLOYMENT_SIZE: 1 SQUADRON(S)
ORGANIZATIONAL MAINTENANCE
MMH/S AT SENSITIVITY VALUE OF 0.50 = 6.69 LOWER LIMIT = 8.3
JET ENGINE SHOP
MMH/S AT SENSITIVITY VALUE OF 1.70 = 11.67 UPPER LIMIT = 11.0
ORGANIZATIONAL MAINTENANCE
MMH/S AT SENSITIVITY VALUE OF 2.10 = 28.08 UPPER LIMIT = 25.5

2 SQUADRONS, ONE-WAY

VARIABLE VALUE	0.50	0.90	1.30	1.70	2.10	2.50
TOTAL BASE MANNING	949	1094	1220	1338	1447	1550
CHIEF OF MAINTENANCE	107	107	107	107	107	107
ORGANIZATIONAL MAINTENANCE	157	209	256	302	345	387
FIELD MAINTENANCE	269	321	366	407	445	480
AVIONICS MAINTENANCE	127	168	202	233	261	287
MUNITIONS MAINTENANCE	289	289	289	289	289	289

ANALYSIS OF VALUES OF INDEPENDENT VARIABLES IN THE LCOM WORK CENTER EQUATIONS:

** THE FOLLOWING EXCEPTIONS WERE NOTED **

DEPLOYMENT_SIZE: 2 SQUADRON(S)
ORGANIZATIONAL MAINTENANCE
MMH/S AT SENSITIVITY VALUE OF 0.50 = 6.69 LOWER LIMIT = 8.3
JET ENGINE SHOP
MMH/S AT SENSITIVITY VALUE OF 1.70 = 11.67 UPPER LIMIT = 11.0
ORGANIZATIONAL MAINTENANCE
MMH/S AT SENSITIVITY VALUE OF 2.10 = 28.08 UPPER LIMIT = 25.5

Table 10 (Cont.)

3 SQUADRONS, TWO WAYS

VARIABLE VALUE	0.50	0.90	1.30	1.70	2.10	2.50
TOTAL BASE MANNING	1449	1686	1893	2083	2260	2429
CHIEF OF MAINTENANCE	146	146	146	146	146	146
ORGANIZATIONAL MAINTENANCE	248	330	405	476	544	610
FIELD MAINTENANCE	423	508	581	648	709	768
AVIONICS MAINTENANCE	211	281	340	392	440	484
MUNITIONS MAINTENANCE	421	421	421	421	421	421

ANALYSIS OF VALUES OF INDEPENDENT VARIABLES IN THE LCOM WORK CENTER EQUATIONS:

** THE FOLLOWING EXCEPTIONS WERE NOTED **

DEPLOYMENT_SIZE: 2 SQUADRON(S)
ORGANIZATIONAL MAINTENANCE
MMH/S AT SENSITIVITY VALUE OF 0.50 = 6.69 LOWER LIMIT = 8.3
JET ENGINE SHOP
MMH/S AT SENSITIVITY VALUE OF 1.70 = 11.67 UPPER LIMIT = 11.0
ORGANIZATIONAL MAINTENANCE
MMH/S AT SENSITIVITY VALUE OF 2.10 = 28.08 UPPER LIMIT = 25.5
DEPLOYMENT_SIZE: 1 SQUADRON(S)
ORGANIZATIONAL MAINTENANCE
MMH/S AT SENSITIVITY VALUE OF 0.50 = 6.69 LOWER LIMIT = 8.3
JET ENGINE SHOP
MMH/S AT SENSITIVITY VALUE OF 1.70 = 11.67 UPPER LIMIT = 11.0
ORGANIZATIONAL MAINTENANCE
MMH/S AT SENSITIVITY VALUE OF 2.10 = 28.08 UPPER LIMIT = 25.5

3 SQUADRONS, ONE WAY

VARIABLE VALUE	0.50	0.90	1.30	1.70	2.10	2.50
TOTAL BASE MANNING	1288	1480	1649	1804	1948	2088
CHIEF OF MAINTENANCE	131	131	131	131	131	131
ORGANIZATIONAL MAINTENANCE	218	290	357	420	480	539
FIELD MAINTENANCE	359	428	487	541	591	639
AVIONICS MAINTENANCE	159	210	253	291	325	358
MUNITIONS MAINTENANCE	421	421	421	421	421	421

ANALYSIS OF VALUES OF INDEPENDENT VARIABLES IN THE LCOM WORK CENTER EQUATIONS:

** THE FOLLOWING EXCEPTIONS WERE NOTED **

DEPLOYMENT_SIZE: 3 SQUADRON(S)
ORGANIZATIONAL MAINTENANCE
MMH/S AT SENSITIVITY VALUE OF 0.50 = 6.69 LOWER LIMIT = 8.3
JET ENGINE SHOP
MMH/S AT SENSITIVITY VALUE OF 1.70 = 11.67 UPPER LIMIT = 11.0
ORGANIZATIONAL MAINTENANCE
MMH/S AT SENSITIVITY VALUE OF 2.10 = 28.08 UPPER LIMIT = 25.5

SENSITIVITY VARIABLE = PEACETIME SORTIE RATE

VARIABLE VALUE	0.60	0.70	0.80	0.90	1.00
TOTAL FLEET MANNING	38165	38210	38295	38546	38977
CHIEF OF MAINTENANCE	3519	3564	3649	3741	3833
ORGANIZATIONAL MAINTENANCE	7209	7209	7209	7209	7209
FIELD MAINTENANCE	11337	11337	11337	11496	11835

Table 10 (Cont.)

AVIONICS MAINTENANCE	6236	6236	6236	6236	6236		
MUNITIONS MAINTENANCE	9864	9864	9864	9864	9864		
1 SQUADRON, ONE-WAY							
VARIABLE VALUE	0.60	0.70	0.80	0.90	1.00		
TOTAL BASE MANNING	687	689	690	694	699		
CHIEF OF MAINTENANCE	88	90	91	92	93		
ORGANIZATIONAL MAINTENANCE	120	120	120	120	120		
FIELD MAINTENANCE	201	201	201	204	208		
AVIONICS MAINTENANCE	120	120	120	120	120		
MUNITIONS MAINTENANCE	158	158	158	158	158		
2 SQUADRONS, ONE-WAY							
VARIABLE VALUE	0.60	0.70	0.80	0.90	1.00		
TOTAL BASE MANNING	1103	1105	1108	1115	1128		
CHIEF OF MAINTENANCE	104	106	109	112	115		
ORGANIZATIONAL MAINTENANCE	207	207	207	207	207		
FIELD MAINTENANCE	326	326	326	330	340		
AVIONICS MAINTENANCE	177	177	177	177	177		
MUNITIONS MAINTENANCE	289	289	289	289	289		
3 SQUADRONS, TWO WAYS							
VARIABLE VALUE	0.60	0.70	0.80	0.90	1.00		
TOTAL BASE MANNING	1709	1710	1713	1723	1741		
CHIEF OF MAINTENANCE	144	145	148	151	154		
ORGANIZATIONAL MAINTENANCE	328	328	328	328	328		
FIELD MAINTENANCE	519	519	519	526	541		
AVIONICS MAINTENANCE	297	297	297	297	297		
MUNITIONS MAINTENANCE	421	421	421	421	421		
3 SQUADRONS, ONE WAY							
VARIABLE VALUE	0.60	0.70	0.80	0.90	1.00		
TOTAL BASE MANNING	1492	1493	1497	1509	1529		
CHIEF OF MAINTENANCE	129	130	134	139	144		
ORGANIZATIONAL MAINTENANCE	286	286	286	286	286		
FIELD MAINTENANCE	435	435	435	442	457		
AVIONICS MAINTENANCE	221	221	221	221	221		
MUNITIONS MAINTENANCE	421	421	421	421	421		
SENSITIVITY VARIABLE = WARTIME SORTIE RATE							
VARIABLE VALUE	0.60	0.70	0.80	0.90	1.00	1.10	1.20
TOTAL FLEET MANNING	31257	32821	34430	35997	37849	39687	41680
CHIEF OF MAINTENANCE	3588	3588	3588	3588	3588	3588	3627
ORGANIZATIONAL MAINTENANCE	5415	5905	6404	6895	7391	7898	8403
FIELD MAINTENANCE	8503	9070	9661	10263	11061	11927	12839
AVIONICS MAINTENANCE	6236	6236	6236	6236	6236	6236	6236
MUNITIONS MAINTENANCE	7515	8022	8541	9015	9573	10038	10575
1 SQUADRON, ONE-WAY							
VARIABLE VALUE	0.60	0.70	0.80	0.90	1.00	1.10	1.20
TOTAL BASE MANNING	582	606	631	658	689	718	749
CHIEF OF MAINTENANCE	90	90	90	90	90	90	90
ORGANIZATIONAL MAINTENANCE	90	98	106	114	123	131	139
FIELD MAINTENANCE	156	166	176	188	201	215	231
AVIONICS MAINTENANCE	120	120	120	120	120	120	120
MUNITIONS MAINTENANCE	126	132	139	146	155	162	169

ANALYSIS OF VALUES OF INDEPENDENT VARIABLES IN THE LCOM WORK CENTER

Table 10 (Cont.)

EQUATIONS:

** THE FOLLOWING EXCEPTIONS WERE NOTED **

DEPLOYMENT_SIZE: 1 SQUADRON(S)
WARTIME SORTIE RATE = 0.60 LOWER LIMIT = .64

2 SQUADRONS, ONE-WAY

VARIABLE VALUE	0.60	0.70	0.80	0.90	1.00	1.10	1.20
TOTAL BASE MANNING	905	949	999	1043	1096	1148	1205
CHIEF OF MAINTENANCE	107	107	107	107	107	107	108
ORGANIZATIONAL MAINTENANCE	155	169	184	198	212	227	241
FIELD MAINTENANCE	245	261	278	295	318	343	370
AVIONICS MAINTENANCE	177	177	177	177	177	177	177
MUNITIONS MAINTENANCE	221	235	253	266	282	294	309

ANALYSIS OF VALUES OF INDEPENDENT VARIABLES IN THE LCOM WORK CENTER EQUATIONS:

** THE FOLLOWING EXCEPTIONS WERE NOTED **

DEPLOYMENT_SIZE: 2 SQUADRON(S)
WARTIME SORTIE RATE = 0.60 LOWER LIMIT = .64

3 SQUADRONS, TWO WAYS

VARIABLE VALUE	0.60	0.70	0.80	0.90	1.00	1.10	1.20
TOTAL BASE MANNING	1392	1464	1535	1606	1689	1772	1862
CHIEF OF MAINTENANCE	146	146	146	146	146	146	148
ORGANIZATIONAL MAINTENANCE	246	268	290	313	335	358	381
FIELD MAINTENANCE	385	412	440	467	504	543	584
AVIONICS MAINTENANCE	297	297	297	297	297	297	297
MUNITIONS MAINTENANCE	318	341	362	383	407	428	452

ANALYSIS OF VALUES OF INDEPENDENT VARIABLES IN THE LCOM WORK CENTER EQUATIONS:

** THE FOLLOWING EXCEPTIONS WERE NOTED **

DEPLOYMENT_SIZE: 2 SQUADRON(S)
WARTIME SORTIE RATE = 0.60 LOWER LIMIT = .64
DEPLOYMENT_SIZE: 1 SQUADRON(S)
WARTIME SORTIE RATE = 0.60 LOWER LIMIT = .64

3 SQUADRONS, ONE WAY

VARIABLE VALUE	0.60	0.70	0.80	0.90	1.00	1.10	1.20
TOTAL BASE MANNING	1212	1276	1339	1402	1477	1553	1635
CHIEF OF MAINTENANCE	131	131	131	131	131	131	133
ORGANIZATIONAL MAINTENANCE	216	236	256	275	295	315	336
FIELD MAINTENANCE	326	347	369	392	423	458	493
AVIONICS MAINTENANCE	221	221	221	221	221	221	221
MUNITIONS MAINTENANCE	318	341	362	383	407	428	452

ANALYSIS OF VALUES OF INDEPENDENT VARIABLES IN THE LCOM WORK CENTER EQUATIONS:

** THE FOLLOWING EXCEPTIONS WERE NOTED **

DEPLOYMENT_SIZE: 3 SQUADRON(S)
WARTIME SORTIE RATE = 0.60 LOWER LIMIT = .64

IV. MODEL VALIDATION AND LIMITATIONS

The model described in this report is the second version of MANPOWER. The original was completed in December 1977 and installed soon after on Department of Defense computers. The present version incorporates modifications based on the results of validation runs using new F-4E and A-10 data. The details of the validation exercises are presented in the technical appendix (Vol. II).

In brief, the following major modifications to version one of MANPOWER were made after analysis of the two test cases.

1. The LCOM shop equations were changed to reflect the new data points.
2. Repair and reclamation (work center 2331) was removed from the category of standard manned shops and included with the Field Maintenance LCOM shops.
3. A guaranteed minimum manning of six per shop in Field and Avionics Maintenance was added; previously, MANPOWER provided no minimum manning except that implied by the constant value in the manning equation.
4. User may specify the number of shops in Avionics Maintenance; previously, this was determined by the program.
5. An allocation of one position per "alert" aircraft is generated if specified by the user; this option was not available previously.

LIMITATIONS

Despite efforts to make MANPOWER a flexible tool, several limitations should be emphasized.

First, the model assumes the traditional Tactical Air Command "66-1" organization of the maintenance activity. It is not applicable to the personnel requirements of alternative organizational structures such as the Production Oriented Maintenance Organization or the Centralized Intermediate Logistics Concept. Because TAC uses the POMO regulation, AFR 66-5, and not the traditional AFM 66-1, Maintenance organization, the model does not conform to current Air Force policy.

Second, the manning equations for the LCOM shops are not relevant for sortie rates radically different from those used in the simulations that provided the data base for the equations. These rates have ranged from about .6 to 1.4. If wartime sortie rates of 2.0 to 4.0 (i.e., surge rates) are input, MANPOWER will greatly overestimate the personnel requirement.

Finally, while MANPOWER can predict the impact of changes in failure rates and repair times on the personnel requirements in the LCOM shops, its greatest utility lies in its capacity to determine total requirements for a range of fleet sizes deployed in diverse patterns. Since the manning that is dependent on system reliability and maintainability represents typically 50 percent of the total requirement, a change in the failure rate or repair time of a subsystem will usually have only a small impact on the overall personnel implications of acquiring the weapon system.

FUTURE WORK

The original version of MANPOWER was designed with the assumption that the workload estimates for the prospective weapon system would be gross and highly aggregated. Thus, manning equations for the LCOM shops were limited to four major areas and the user was asked to supply MMH/FH.

The desire to assess the impact of changes in reliability and maintainability on personnel requirements led to the development of the new input options available in the second version of MANPOWER. The user can now supply MTBF and MTTR in 37 second-digit work unit code categories.

The model, however, still uses only four basic equations to estimate the manpower requirements for 15 to 20 LCOM shops. The MTBF and MTTR estimates provided by the user are translated to maintenance manhours and these are aggregated to the four work center groups.

The next logical step in this evolution is to develop unique equations for each LCOM work center. As more LCOM simulation studies become available, the differences between the shops in the relationship between personnel requirements, on the one hand, and workload and aircraft utilization rates, on the other, can be more accurately estimated. Initial efforts in this detailed shop-by-shop analysis are presented in the technical appendix (Vol. II).

Finally, further investigations will be needed to adapt MANPOWER to innovative organizational structures. Any change in the organization of the maintenance activity that alters the personnel utilization rate in the LCOM shops will require modification of the prediction equations.

Appendix

INPUT DATA REQUIREMENTS

Card 1.01, Aircraft Type, Columns 1-20, Format: A(20).

MANPOWER accepts: RECONNAISSANCE, FIGHTER, or ATTACK.

Card 2.01, Detailed Output Option, Columns 1-2, Format: F(2).

If detail option equals 0, then manning by deployment pattern is printed only for the five major maintenance divisions: Chief of Maintenance, Organizational Maintenance, Field Maintenance, Avionics Maintenance, and Munitions Maintenance. If detail option equals 1, then manning by deployment pattern is printed for LCOM simulated shops, standard manned shops, and overhead and supervision within each of the five divisions (as well as division totals).

Card 3.01, Avionics Indicator, Columns 1-4, Format: 2(F(2)).

In columns 1-2, if avionics indicator equals 0, then the "nonintegrated" avionics portion of MANPOWER will be executed. If avionics indicator equals 1, then the "integrated" avionics portion of MANPOWER will be executed.

In columns 3-4, indicate the number of shops in Avionics Maintenance.

Card 4.01, Maintenance Hours Indicator, Columns 1-2, Format: F(2).

If maintenance hours indicator equals 0, user-supplied maintenance workload assumptions must be in terms of MMH/FH in four work center groups. (These groups are listed under Card 5.01.)

If maintenance hours indicator equals 1, user-supplied maintenance workload assumptions must be in terms of MMH/S in seven work unit code categories. (These categories are listed under Card 5.01.)

If maintenance hours indicator equals 2, user-supplied maintenance workload assumptions must be in terms of MTBF and MTTR in 37 (or more) second-digit work unit code categories and MMH/S for general support. (The second-digit work unit code categories are listed under Card 5.01.)

If maintenance hours indicator equals 3, user-supplied maintenance workload assumptions must be in terms of MTBF, MTTR, and distribution factors for 37 (or more) second-digit work unit code categories and MMH/S for general support.

Cards 5.01 to 5.XX, Maintenance Workload Assumptions:

A. If maintenance hours indicator = 0, Card 5.01, columns 1-20, format: 4(F(5,1)). MMH/FH must be supplied in the following categories:

   1. Flight Line Maintenance and Inspection: columns 1-5, F(5,1).
   2. Aerospace Systems Shops, Repair and Reclamation, and Structural Repair: columns 6-10, F(5,1).
   3. Jet Engine Shop: columns 11-15, F(5,1).
   4. Avionics Maintenance Shops: columns 16-20, F(5,1).

B. If maintenance hours indicator = 1, Card 5.01, columns 1-70, format: 7(F(10,2)). MMH/S must be supplied in the following categories:

   1. Aircraft support general (work unit code = 0): columns 1-10, F(10,2).
   2. Air frame, landing gear, and flight control (work unit code = 1): columns 11-20, F(10,2).
   3. Propulsion system (work unit code = 2): columns 21-30, F(10,2).
   4. Aerospace systems (work unit codes = 3,4): columns 31-40, F(10,2).
   5. Instruments and automatic flight control (work unit code = 5): columns 41-50, F(10,2).
   6. Communication, navigation, and mission systems (work unit codes = 6,7): columns 51-60, F(10,2).
   7. TOW target and personnel equipment (work unit codes = 8,9): columns 61-70, F(10,2).

C. If maintenance hours indicator = 2, Cards 5.01 to 5.38 plus optional cards. The following information must be supplied:

1. Cards 5.01 to 5.37, columns 1-20, format: 2(F(10,2)). MTBF (columns 1-10, F(10,2)) and MTTR (columns 11-20, F(10,2)) for the following second-digit work unit code categories (work unit code number precedes category name).

11 Air Frame
12 Cockpit and Fuselage Compartments
13 Landing Gear System
14 Flight Controls
16 Escape Capsule
23 Power Plant
24 Secondary Power System
41 Environmental Control System
42 Electrical System
44 Lighting System
45 Hydraulic System
46 Fuel System
47 Oxygen System
49 Miscellaneous Utilities
51 Instruments
52 Auto Pilot
55 Malfunction Analysis Equipment
57 Guidance and Flight Control System
61 HF Communications
62 VHF Communications
63 UHF Communications
64 Interphone
65 Identification Friend or Foe (IFF) System
69A Communication and Navigation Package
69B Miscellaneous Communications Equipment
71 Radio Navigation
72 Radar Navigation
73 Bombing Navigation
74 Fire Control System
75 Weapons Delivery System
76 Electronic Countermeasures
77 Photo/Reconnaissance
91 Emergency Equipment
92 TOW Target Equipment
93 Drag Chute Equipment
96 Personnel and Miscellaneous Equipment
97 Explosive Devices

2. Card 5.38, columns 1-20, format: F(10,2), F(10). MMH/S in general support (work unit code = 0, columns 1-10, F(10,2)) and integer (A) indicating the number of new systems for which failure rates and repair times will be input (columns 11-15, F(10)).
3. If A > 0, Cards 5.39 to 5.38 + A, columns 1-25, format: 2(F(10,2)), F(5). MTBF (columns 1-10, F(10,2)), MTTR (columns 11-20, F(10,2)), and first-digit work unit code to which this new system will be assigned (columns 21-25, F(5)).

D. If maintenance hour indicator = 3, Cards 5.01 to 5.38 plus optional cards. The following information must be supplied:
   1. Cards 5.01 to 5.37, columns 1-60, format: 6(F(10,2)). This information must be supplied for each of the second-digit work unit code categories listed in (C) above:
      a. MTBF: columns 1-10, F(10,2).
      b. MTTR: columns 11-20, F(10,2).
      c. Percentage of workload in this category performed by Flight Line Maintenance and Inspection Shops. Input as 0.XX: columns 21-30, F(10,2).
      d. Percentage of workload in this category performed by Aerospace Systems, Repair and Reclamation, and Structural Repair Shops. Input as 0.XX: columns 31-40, F(10,2).
      e. Percentage of workload in this category performed by the Jet Engine Shop. Input as 0.XX: columns 41-50, F(10,2).
      f. Percentage of workload in this category performed by Avionics Maintenance Shops. Input as 0.XX: columns 51-60, F(10,2).
   2. Card 5.38, columns 1-60, format: F(10,2), F(10), 4(F(10,2)). Provide the following data:

Table 11

DISTRIBUTION OF WORK ON THE F-4E IN WORK CENTER GROUPS
(In percent)

Two-Digit Work Unit Code		Work Center Group: Flight Line	Field Maintenance	Jet Engine	Avionics
11	Air Frame	22.90	76.62	0.22	0.26
12	Cockpit and Fuselage Compartments	37.12	58.88	0.00	3.99
13	Landing Gear System	41.23	57.61	0.18	0.98
14	Flight Controls	30.77	66.64	0.01	2.58
16	Escape Capsule	0.00	100.00	0.00	0.00
23	Power Plant	3.57	6.28	85.72	4.44
24	Secondary Power System	0.00	0.00	0.00	100.00
41	Environmental Controls	1.52	76.79	10.50	11.20
42	Electrical System	10.34	65.68	6.35	17.63
44	Lighting System	19.34	74.72	0.00	5.94
45	Hydraulic System	4.79	92.21	0.26	2.74
46	Fuel System	3.43	93.33	0.01	3.22
47	Oxygen System	4.31	95.69	0.00	0.00
49	Miscellaneous Utilities	7.50	92.50	0.00	0.00
51	Instruments	0.77	2.87	0.00	96.35
52	Auto Pilot	0.07	0.64	0.00	99.29
55	Malfunction Analysis	1.47	0.00	0.00	98.53
57	Guidance and Flight Controls	0.00	0.00	0.00	0.00
61	HF Communications	0.00	0.00	0.00	0.00
62	VHF Communications	0.00	0.00	0.00	0.00
63	UHF Communications	0.00	0.00	0.00	0.00
64	Interphone	100.00	0.00	0.00	0.00
65	IFF System	0.00	0.00	0.00	0.00
69	Communication and Navigation	0.00	0.00	0.00	0.00
71	Radio Navigation	0.05	0.02	0.00	99.93
72	Radar Navigation	0.22	0.21	0.00	99.57
73	Bombing Navigation	0.08	0.06	0.00	99.86
74	Fire Control System	0.01	0.06	0.00	99.92
75	Weapons Delivery System	9.00	69.42	0.00	21.59
76	ECM	0.24	0.18	0.01	99.57
77	Photo/Reconnaissance	0.37	2.52	0.00	97.10
91	Emergency Equipment	0.00	100.00	0.00	0.00
92	TOW Target Equipment	27.28	72.72	0.00	0.00
93	Drag Chute Equipment	63.40	34.52	0.00	2.08
96	Personnel and Miscellaneous Equipment	12.40	71.52	0.00	16.08
97	Explosive Devices	0.00	100.00	0.00	0.00

Table 12

DISTRIBUTION OF WORK ON THE F-15 IN WORK CENTER GROUPS
(In percent)

Two-Digit Work Unit Code		Work Center Group			
		Flight Line	Field Maintenance	Jet Engine	Avionics
11	Air Frame	15.08	78.59	0.00	6.33
12	Cockpit and Fuselage Compartments	32.21	61.88	0.00	5.92
13	Landing Gear System	26.50	72.20	0.00	1.29
14	Flight Controls	33.38	61.13	0.00	5.50
16	Escape Capsule	0.00	100.00	0.00	0.00
23	Power Plant	2.67	6.44	88.47	2.42
24	Secondary Power System	7.88	15.74	75.60	0.78
41	Environmental Controls	5.00	90.26	0.30	4.44
42	Electrical System	2.07	60.38	1.37	36.18
44	Lighting System	8.89	76.47	0.00	14.64
45	Hydraulic System	2.56	87.30	0.00	10.15
46	Fuel System	1.20	89.34	0.29	9.17
47	Oxygen System	6.31	74.44	0.00	19.25
49	Miscellaneous Utilities	6.53	93.08	0.00	0.39
51	Instruments	0.73	3.07	0.00	96.21
52	Auto Pilot	0.09	0.56	0.00	99.35
55	Malfunction Analysis	0.47	6.06	0.00	93.47
57	Guidance and Flight Controls	0.06	0.00	0.00	99.94
61	HF Communications	0.00	0.00	0.00	0.00
62	VHF Communications	0.00	0.00	0.00	0.00
63	UHF Communications	0.13	0.47	0.00	99.40
64	Interphone	0.00	0.00	0.00	0.00
65	IFF System	0.05	0.14	0.00	99.82
69	Communication and Navigation	0.00	0.00	0.00	9.00
71	Radio Navigation	0.07	0.41	0.00	99.53
72	Radar Navigation	0.00	0.00	0.00	0.00
73	Bombing Navigation	0.00	0.00	0.00	100.00
74	Fire Control System	0.15	0.16	0.00	99.69
75	Weapons Delivery System	2.44	44.96	0.00	52.60
76	ECM	1.81	2.10	0.00	96.10
77	Photo/Reconnaissance	0.00	100.00	0.00	0.00
91	Emergency Equipment	23.21	72.49	0.00	4.30
92	TOW Target Equipment	0.00	0.00	0.00	0.00
93	Drag Chute Equipment	0.00	0.00	0.00	100.00
96	Personnel and Miscellaneous Equipment	0.00	0.00	0.00	0.00
97	Explosive Devices	0.00	100.00	0.00	0.00

a. MMH/S in general support (work unit code = θ, columns 1-10, F(10,2)).

b. Integer (A) indicating the number of new systems for which failure rates, repair times, and distribution factors will be input (columns 11-20, F(10)).

c. Distribution factors for general support workload. Input as described in D.1.c-f, above.

3. If A > 0, Cards 5.39 to 5.38 + A, columns 1-60, format: 6(F(10,2)). Input same data as described in D.1.a-f, above, for each new system.

Tables 11-12 present illustrative distribution factors for the F-4E and F-15. Where the percentage equals zero, either the workload per 100 sorties was extremely small or the aircraft did not have the particular subsystem. The distribution factors for general support (work unit code = 0 can be obtained from Table 5. (See the technical appendix (Vol. II) for a discussion of the derivation of the F-4E and F-15 factors.) These factors are presented as examples--the model user will want to adjust his factors to reflect different expectations about the prospective aircraft.

Card 6.01, Aircraft and Alert Aircraft per Squadron, Columns 1-20, Format: 2(F(10,2)).

A. Aircraft per squadron: columns 1-10, F(10,2).

B. Alert aircraft per squadron: columns 11-20, F(10,2).

Card 7.01, Peacetime and Wartime Sortie Rates, Columns 1-20, Format: 2(F(10,2)).

A. Peacetime sortie rate*: columns 1-10, F(10,2).

B. Wartime sortie rate: columns 11-20, F(10,2).

Card 8.01, Peacetime and Wartime Sortie Lengths, Columns 1-20, Format: 2(F(10,2)).

A. Peacetime sortie length*: columns 1-10, F(10,2).

B. Wartime sortie length: columns 11-20, F(10,2).

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*If peacetime factors are unknown, leave this field blank. The program will make appropriate adjustments in the calculations.

Card 9.01, Air Superiority Missions, Columns 1-10, Format: F(10,2).

Proportion of sorties that are air superiority missions. Input as 0.XX.

Cards 10.01 to 25.01, Model Parameters.

Cards 10.01 to 25.01 contain model parameters.

Card 26.01, AGE Management (Work Center 2340), Columns 1-52, Format: 13(F(4,0)).

Required manning in this work center:

Columns	Requirements
1-4	3
5-8	4
9-12	4
13-16	5
17-20	5
21-24	5
25-28	6
29-32	6
33-36	6
37-40	6
41-44	7
45-48	7
49-52	8

Card 27.01, AGE Repair and Inspection (Work Center 2341) for Reconnaissance Aircraft, Columns 1-15, Format: 3(F(5,0)).

If aircraft type is reconnaissance, these minimum manning requirements per squadron for work center 2341 are in effect:

Columns	Minimum Requirements
1-5	6
6-10	8
11-15	10

Insert a blank card if the aircraft type is not reconnaissance.

Card 28.01, AGE Repair and Inspection for Nonreconnaissance Aircraft (Work Center 2341), Columns 1-20, Format: 2(F(10,3)).

A. If aircraft type is *not* reconnaissance and the avionics type is "integrated," the following factors should be input:

Columns	Factor
1-10	6.2
11-20	6.2

B. If aircraft type is *not* reconnaissance and the avionics type is "nonintegrated," the following factors should be input:

Columns	Factor
1-10	3.49
11-20	3.49

Insert a blank card if the aircraft type is reconnaissance.

Card 29.01, AGE Service, Pickup, and Delivery for Nonreconnaissance Aircraft (Work Center 2342), Columns 1-20, Format: 2(F(10,3)).

A. If aircraft type is *not* reconnaissance and the avionics type is "integrated," the following factors should be input:

Columns	Factor
1-10	7.9
11-20	7.9

B. If aircraft type is *not* reconnaissance and the avionics type is "nonintegrated," the following factors should be input:

Columns	Factor
1-10	4.44
11-20	4.44

Insert a blank card if the aircraft type is reconnaissance.

Card 30.01, AGE Service, Pickup, and Delivery (Work Center 2342) for Reconnaissance Aircraft, Columns 1-15, Format: 3(F(5,0)).

If aircraft type is reconnaissance, the minimum manning requirements per squadron for work center 2342 are in effect.

Columns	Minimum Requirement
1-5	6
6-10	8
11-15	10

Insert a blank card if the aircraft type is not reconnaissance.

Card 31.01, Number of Deployments, Columns 1-2, Format: F(2).

Specify the number (N) of different deployment patterns that will be described on the cards that follow. For example, if bases are to have deployment patterns of three squadrons/two ways, two squadrons/one way, one squadron/one way, and three squadrons/three ways, then Card 31.01 would indicate four deployment patterns (N = 4).

Card 32.01 to 32.XX, Deployment Pattern Identifiers, Columns 1-60. Format: A(3), 2(F(5)), X(7), 4(F(10)).

One card of this type is needed for *each* of the N different deployment patterns postulated by the user. The following information is required:

1. Deployment pattern (columns 1-3, A(3)). The deployment pattern is expressed as number of squadrons-number of deployments. Thus, for example, 3-2, 2-1, and 4-3 indicate three squadrons (based together in peacetime) deploying two ways in wartime, two squadrons deploying one way, and four squadrons deploying three ways, respectively.
2. Number of bases (columns 4-8, F(5)). Specify the number of peacetime bases for this deployment pattern.
3. Number of squadrons (columns 9-13, F(5)). Specify the number of squadrons based together in peacetime for this deployment pattern. (This is the same number as specified in column 1.)
4. Deployment unit sizes (columns 21-60, 4(F(10)). A "deployment unit" is defined as a number of squadrons that can be deployed to a separate location in wartime. For example, a peacetime base that has three squadrons deploying two ways would have two deployment units--one consisting of two squadrons and the other of one squadron; a peacetime base

that has four squadrons deploying four ways would have four deployment units, with one squadron in each. Columns 21-60 contain four fields of ten columns; each field represents a deployment unit. The user is required to enter the number of squadrons in each deployment unit in one or more of the four fields. Continuing the two examples, these entries are required on the two deployment pattern identification cards:

Columns	Deployment Patterns 3-2	4-4
20-30	2	1
31-40	1	1
41-50	0	1
51-60	0	1

Card 33.01, Number of Sensitivity Codes, Columns 1-2, Format: F(2).

Enter the number (P) of different types of sensitivity analyses that are to be performed on this computer run. There are seven different types described on the next card.

Card 34.01 to 34.XX, Sensitivity Analyses, Columns 1-40, Format: F(2), X(8), 3(F(10,2)).

One card of this type is required for *each* of the P different sensitivity analyses desired by the user. The following information must be specified:

1. Sensitivity code (columns 1-2, F(2)). The appropriate sensitivity code should be entered for the desired analysis. The codes are listed below.
2. Low sensitivity value (columns 11-20, F(10,2)). This and the next input value specify the range of the sensitivity analysis.
3. High sensitivity value (columns 21-30, F(10,2)).
4. Sensitivity increment (columns 31-40, F(10,2)). The high sensitivity value minus the low sensitivity value, divided by the sensitivity increment, must yield an integer value less than or equal to 9. This calculation (plus 1) determines the number of sensitivity levels.

The sensitivity codes are:

Code	Sensitivity Analysis of:
1	Flight Line MMH/FH
2	Jet Engine Shop MMH/FH
3	Aerospace Systems, Repair and Reclamation, and Structural Repair MMH/FH
4	Avionics MMH/FH
5	Total MMH/FH or MMH/S (percent of base case)
6	Peacetime sortie rate
7	Wartime sortie rate

Section III provides additional instructions on coding the sensitivity analyses.

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