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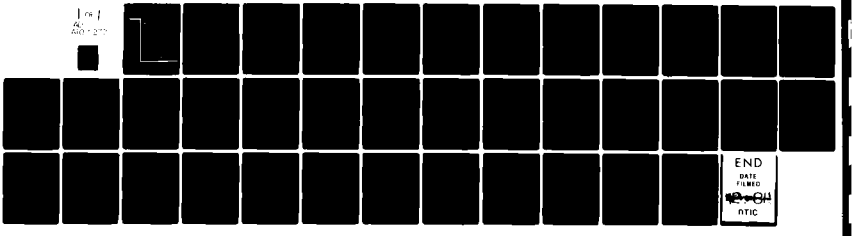

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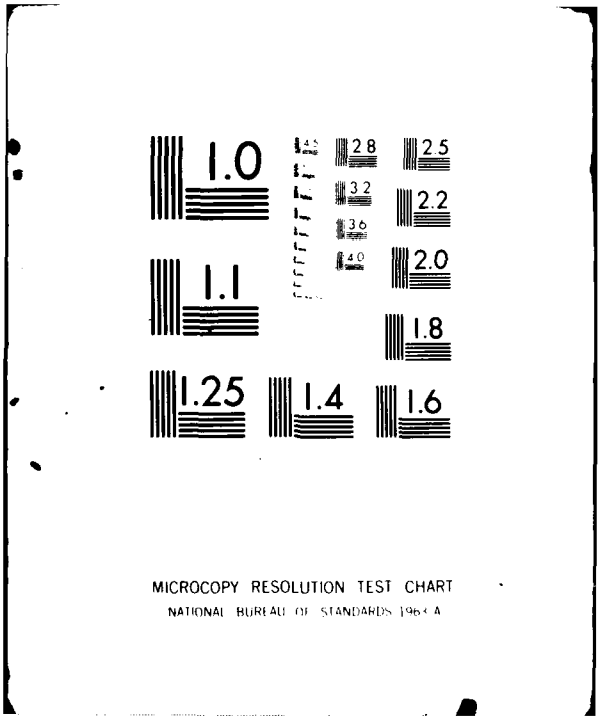
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MISSION IMPACT GENERALIZED EXPLANATORY BASE OPERATING SUPPORT MODEL DEVELOPMENT: FINAL MANAGEMENT SUMMARY

By

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September 1981

Final Report

AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235

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The Public Affairs Office has reviewed this paper, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

This paper has been reviewed and is approved for publication.

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ERRATA

AFHRL-TP-81-30 MISSION IMPACT GENERALIZED EXPLANATORY BASE OPERATING SUPPORT MODEL DEVELOPMENT: FINAL MANAGEMENT SUMMARY

Due to printing error, certain lines of type cannot be read. Make pen and ink changes in text as follows:

Page 18, fourth line should read as follows:

"identifies the mission capability/support workload relationships devel—"

Page 24, fourth line should read as follows:

"in terms of mission capabilities."

Page 26, last column of Table 10 should read as follows:

"Administration
Retail Supply
Maintenance of Installation Equipment
Other Base Services
Bachelor Housing
Morale, Welfare, and Recreation
Other Personnel Support"

Page 28, second line should read as follows:

"through construction and validation of the GEBOS-M model, the feasibility"

Page 30, third and fourth lines should read as follows:

"— A programmatic FYDP capability will also allow full coverage of manpower/workload leads and lags."

E.L. ELLIOTT
Chief, Technical Editing Office

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)*

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18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Mission Impact Generalized Explanatory Base Operating Support Model (GEBOS-M); Base Operating Support (BOS); Manpower and Workload Indicators; Manpower Planning; Mathematical Modeling; Real Property Maintenance Activities (RPMA); Mission Capability Indicators; Linear Programming Applications

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

The Mission Impact Generalized Explanatory Base Operating Support Model (GEBOS-M) can compute Air Force Major Command (MAJCOM) Base Operating Support (BOS) and Real Property Maintenance Activities (RPMA) manpower requirements directly from programmed changes in mission elements. GEBOS-M provides manpower managers with a quick turnaround capability to program and justify base level support manpower changes in functional category level of detail, tied directly to changes in mission capability. This test model applies to Strategic Air Command (SAC), Tactical Air Command (TAC), and Air Training Command (ATC)/U.S. Air Force Academy (USAFA). With further work, it can be extended to apply Air Force-wide. Initial validation tests were completed. They demonstrated consistent and reliable relationships between primary

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Item 20 (Continued):

mission activities and their supporting BOS/RPMA workload and manpower levels. The supporting manpower and workload elements addressed by the model include all Department of Defense (DOD) functional categories comprising the BOS/RPMA program elements.

AFHRL Technical Paper 81-30 September 1981

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CONTENTS

SECTION 1

PROJECT OVERVIEW

This is a management summary of the research performed by General Research Corporation (GRC) on the Development of a Mission Impact Generalized Explanatory Base Operating Support (GEBOS) Model, Contract F33615-80-C-0023. The period of performance was 1 December 1980 through 30 June 1981. It was dedicated to an extension of GRC's innovative prior work in developing a prototype GEBOS model.

The Mission Impact GEBOS Model (GEBOS-M) provides Air Force manpower managers with greatly improved capabilities to program and justify base level support manpower. GEBOS-M can compute base operating support (BOS) and real property maintenance activities (RPMA) manpower requirements directly from programmed changes in the mission elements of the force structure, reducing current reliance upon command average manpower factors for support manpower computations.

This document contains a nontechnical presentation of the research conducted by GRC. It provides examples of how the results can be applied to enhance Air Force manpower management. It includes recommendations to extend that enhanced capability Air Force-wide.

CONTRACT REQUIREMENTS

The contract specifications required GRC to perform 7 months of research divided into four phases:

- Phase I. Identify three test major commands (MAJCOMs); and identify, collect, and refine those MAJCOM data elements necessary to construct the computerized data base supporting GEBOS-M.
- Phase II. Develop the GEBOS-M model. Analyze manpower, workload, and mission capability to develop and refine their interactive relationships. Develop the automated capability to selectively change mission structure and concurrently compute base operating support workload and manpower impacts in functional detail.

- Phase III. Develop model validation procedures. Conduct validation exercises comparing model output to the manpower/workload/mission impact results of actual changes in mission elements of the force structure.
- Phase IV. Provide (throughout the contract term) full documentation and briefings on computer software, data files, model operation/output, a technical audit trail, and a non-technical management summary suitable for publication detailing major findings of the whole effort.

ORGANIZATION OF THE REPORT

This management summary consists of the preceding overview followed by four sections:

- Section 2 discusses the purposes and objectives of the research.
- Section 3 describes the methodology used to develop model relationships.
- Section 4 summarizes research results and provides illustrative examples applying the research results to selected manpower programming problems.
- Section 5 provides conclusions and recommendations to implement, refine, and extend these important research results.

SECTION 2

PURPOSE OF THE RESEARCH

Every year, the Directorate of Manpower and Organization (AF/MPM), Headquarters, United States Air Force, must define and assess the impact of BOS and RPMA manpower changes in terms of reduced or increased workload and mission execution capabilities. This occurs on a routine basis as the Five Year Defense Program (FYDP) is developed, updated, and revised. It frequently occurs on an emergent basis when the Air Force manpower program is presented and defended to the Office of the Secretary of Defense (OSD), the Office of Management and Budget (OMB), and the committees of the Congress.

Historically, AF/MPM has estimated these so-called support manpower impacts based upon percentage factors applied to mission manpower changes. Such an approach effectively treats all mission manpower elements as equivalent in terms of their requirement for BOS and RPMA support. A B-52 squadron and a headquarters unit authorized identical manpower levels have the same support manpower needs under such a system. Further, the system only estimates changes at the program element level. Such a program element factor method does not address manpower needs in any functional detail. No consistent, regularized estimate is made as to how functional manpower categories will be affected or how their workload output levels can be expected to change.

Initial research by GRC led to the development, in cooperation with the Air Force Management Engineering Agency (AFMEA), of innovative program estimating equations which identified a series of aggregate manpower/workload indicator relationships. These were used to build an explanatory model capable of accurately estimating the impact of workload changes on BOS and RPMA functional manpower; or, alternatively, the impact of manpower changes in terms of workload execution capability. Initially, these programming tools were not correlated with mission manpower or mission execution capabilities.

The current research and model building effort identified the key relationships between mission manpower/capabilities, and the primary BOS and RPMA manpower and workload indicators. These relationships have enabled GRC to complete and test a programmable mission/support manpower planning model. Given specific mission changes, the GEBOS-M model can accurately estimate changes to primary workload indicators and BOS and RPMA manpower by functional category.

Section 3

Research Approach

A two-phased research effort was required to develop a model capable of programming BOS requirements associated with force structure mission changes. First, the relationship between BOS/RPMA manpower and major workload indicators was developed and refined to identify reliable and consistent estimates of the BOS/RPMA manpower required to perform essential workloads. Next the interaction between these key support workload indicators and primary mission activities was investigated to develop consistent relationships between primary mission activities and their supporting BOS/RPMA workload and manpower levels.

This research approach was carried out in the following steps:

- Identification of BOS/RPMA manpower categories in three test commands: Strategic Air Command (SAC), Tactical Air Command (TAC), and Air Training Command (ATC).
- Identification of candidate BOS/RPMA workload indicators in the test commands.
- Selection of a few workload indicators which, when changed, accurately and reliably "explain" changes in BOS/RPMA manpower.
- Identification of principal mission activities and associated manpower within the test commands.
- Derivation of consistent and reliable relationships between primary mission activities/manpower and the previously identified explanatory BOS/RPMA workload indicators.
- Derivation of other consistent explanatory relationships that exist among related workload indicators.
- Accounting for some of the "support-on-support" manpower needs.

The support manpower and workload elements analyzed included all DOD functional categories that comprise the RPMA and BOS program elements.

These functional categories are listed in Table 1 by program element with the corresponding DOD functional category codes.

Manpower workload relationships for all 10 functional categories were analyzed in each of the three test commands. The associated explanatory workload indicators were identified based upon logical relationships with the work performed in a functional category and strong statistical correlations with functional manpower. The indicator identification process was based upon joint research by GRC and AFMEA, with joint validation of the significant functional manpower explainers which were selected. The selected indicators are listed by functional category in Table 1.

Selection of workload indicators was based upon multivariate regression analysis. GRC used overall explanatory power [in terms of highest proportion of variance (R^2) explained by the independent variables and lowest coefficient of variations] as the principal criterion for selection of variables, along with a logical relationship to functional activities. Where several alternative manpower/workload specifications were identified as reliable, the same workload indicators were applied to the three test commands, enhancing the comparability of results across commands.

Investigation of mission activities began with a review of primary mission manpower and weapon systems for the three test commands. Mission elements and manpower from the Program Document (PD): Bases, Units, and Priorities were analyzed to quantify principal command weapons system structures. Major programmable peacetime mission workload indicator data--such as flying hours by aircraft model/design/series (M/D/S)--were concurrently collected. Table 2 lists the principal relationships identified between weapon systems and mission workload indicators.

Once principal mission workload activities had been identified and quantified, their relationships to support workload indicators were investigated. Both logical and statistical relationships were used in the identification of valid relationships. For example, a consistent

TABLE

BOS AND RPMA FUNCTIONAL CATEGORY [illegible] WORKLOAD INDICATORS

Program Element	Functional Category Code	[illegible]-M Code
11894	Maintenance and Repair of Real Property (FC30)	[illegible], Military Housing Floor Space [illegible], Floor Space (C5), Missile Bases
27594	Maintenance and Repair of Real Property (FC30)	[illegible] Housing Floor Space
85794	Maintenance and Repair of Real Property (FC30)	Military Housing Floor Space (V20)
11894	Operation of Utilities (FC32)	[illegible] Floor Space (C5)
27594	Operation of Utilities (FC32)	[illegible] Floor Space (C5)
85794	Operation of Utilities (FC32)	Base Population (C2), Military Housing Floor Space [illegible]
11894	Other Engineering Support (FC33)	Base Population (C2)
27594	Other Engineering Support (FC33)	Base Population (C2), Military Housing Floor Space [illegible]
85794	Other Engineering Support (FC33)	Base Population (C2), Military Housing Floor Space [illegible], Non-Housing Floor Space (C5)
11896	Administration (FC36)	Base Population (C2), Travel Transactions (V29)
27596	Administration (FC36)	Base Population (C2), Travel Transactions (V29)
85796/ 85896	Administration (FC36)	Base Population (C2), Travel Transactions (V29)
11896	Retail Supply Operations (FC37)	Total Item Records (C7), Aviation Fuel Consumption (V33)
27596	Retail Supply Operations (FC37)	Total Item Records (C7), Aviation Fuel Consumption (V33)
85796/ 85896	Retail Supply Operations (FC37)	Total Item Records (C7), Aviation Fuel Consumption (V33)
11896	Maintenance of Installation Equipment (FC38)	Military Vehicles (V73), Miles Driven (V76)
27596	Maintenance of Installation Equipment (FC38)	Military Vehicles (V73), Miles Driven (V76)
85796/ 85896	Maintenance of Installation Equipment (FC38)	Military Vehicles (V73), Miles Driven (V76)
11896	Other Base Services (FC39)	Base Population (C2)
27596	Other Base Services (FC39)	Base Population (C2)
85796/ 85896	Other Base Services (FC39)	Base Population (C2)
11896	Bachelor Housing Operations (FC40)	Visiting Airmen Beds (V42), Missile Bases (V92)
27596	Bachelor Housing Operations (FC40)	Visiting Airmen Beds (V42)
85796/ 85896	Bachelor Housing Operations (FC40)	Visiting Airmen Beds (V42), Military Population (C3)
11896	Morale, Welfare, and Recreation (FC41)	Military Population (C3)
27596	Morale, Welfare, and Recreation (FC41)	Military Population (C3)
85796/ 85896	Morale, Welfare, and Recreation (FC41)	Students Authorized (V91), Military Population (C3)
11896	Other Personnel Support (FC42)	Base Population (C2), Weighted Rations Served (V72), Missile Bases (V92)
27596	Other Personnel Support (FC42)	Base Population (C2), Weighted Rations Served (V72)
85796/ 85896	Other Personnel Support (FC42)	Weighted Rations Served (V72)

TABLE 2

WEAPON SYSTEMS AND CAPABILITY INDICATORS

Program Element	Command	Weapon System	Capability Indicators
11113	SAC	B-52	Aircraft, Flying Hours, Sorties, Squadrons
11115	SAC	FB-111	Aircraft, Flying Hours, Sorties, Squadrons
11118	SAC	SRAM	B-52G/H Aircraft, Squadrons
11142	SAC	KC-135	Aircraft, Flying Hours, Sorties, Squadrons
11212	SAC	Titan	Missiles, Squadrons
11213	SAC	Minuteman	Missiles, Squadrons
21120	TAC	Airborne Command Post	Aircraft, Flying Hours, Sorties, Squadrons
27121	TAC	A-7	Aircraft, Flying Hours, Sorties, Squadrons
27127	TAC	F-105	Aircraft, Flying Hours, Sorties, Squadrons
27128/ 27597	TAC	F-4	Aircraft, Flying Hours, Sorties, Squadrons
27129/ 27597	TAC	F-111	Aircraft, Flying Hours, Sorties, Squadrons
27130/ 27597	TAC	F-15	Aircraft, Flying Hours, Sorties, Squadrons
27131/ 27597	TAC	A-10	Aircraft, Flying Hours, Sorties, Squadrons
27213/ 27597	TAC	RF-4	Aircraft, Flying Hours, Sorties, Squadrons
27218	TAC	Aggressor Squadron (F-5)	Aircraft, Flying Hours, Sorties, Squadrons
27412	TAC	O-2	Aircraft, Flying Hours, Sorties, Squadrons
32015	SAC	National Emergency Airborne Command Post (E-4)	Aircraft, Flying Hours, Sorties, Squadrons
81714/ 84711	ATC	Personnel Processing and Recruit Training	Recruit Training Workload
84721	ATC	Service Academy	Cadet Training Workload
84731	ATC	General Skill Training	Technician Training Workload
84733/ 84734	ATC	General Intelligence and Crypto Skill Training	Crypto/Intelligence Training Workload
84741/ 84743	ATC	Undergraduate Pilot Training	Aircraft, Flying Hours, Sorties, Squadrons, Pilot Training Workload
84742	ATC	Undergraduate Navigator Training	Aircraft, Flying Hours, Sorties, Squadrons, Navigator Training Workload
84751/ 84752	ATC	Professional Education	Professional Education Training Workload

statistical relationship between B-52 program element manpower and numbers of B-52s assigned was developed. A logical relationship between aviation fuel consumption and B-52 flying hours was developed based upon available B-52 flying hour fuel consumption rates. Table 3 lists the principal mission/support workload indicator relationships identified.

Support workload interrelationships were also investigated. These are applied in the model to assure that interrelated changes in selected workload indicators occur in a balanced fashion. These relationships balance such factors as: military population with total base population, travel transactions processed with total base population, weighted rations served and visiting airmen beds with enlisted population, and miles driven with total base population.

On completion of these analyses, the relationships between mission, workload, and BOS/RPMA manpower were incorporated in the GEBOS-M model. The GEBOS-M model permits Air Force manpower planners to interactively change mission activities and primary mission workload drivers, and forecast their impact on support workload indicators and BOS/RPMA functional manpower.

Figure 1 illustrates the [illegible] methodology. Selected input and output variables are [illegible] the display by way of illustration to aid understanding. The next section of this summary provides further exemplary detail on model computational processes and output.

TABLE 3

RELATIONSHIPS BETWEEN BOS/RPMA WORKLOAD INDICATORS AND MISSION CAPABILITY MEASURES

Program Element	BOS/RPMA Workload Indicator	Mission Capability Indicator
11894	Base Population	Aircraft, Missiles, Squadrons, Direct Mission Manpower
11896	Base Population	Aircraft, Missiles, Squadrons, Direct Mission Manpower
	Total Item Records	Aircraft Squadrons, Missile Squadrons
	Aviation Fuel Consumption	Aircraft Flying Hours
	Miles Driven	Missiles
27594	Base Population	Aircraft, Squadrons, Direct Mission Manpower
27596	Base Population	Aircraft, Squadrons, Direct Mission Manpower
	Total Item Records	Aircraft Squadrons
	Aviation Fuel Consumption	Aircraft Flying Hours
	Miles Driven	Aircraft Sorties
85794	Base Population	Aircraft, Training Workload, Direct Mission Manpower
85796/ 85896	Base Population	Aircraft, Training Workload, Direct Mission Manpower
	Total Item Records	Aircraft, Training Workload
	Aviation Fuel Consumption	Aircraft Flying Hours
	Students Authorized	Training Workload
	Weighted Rations Served	Training Workload

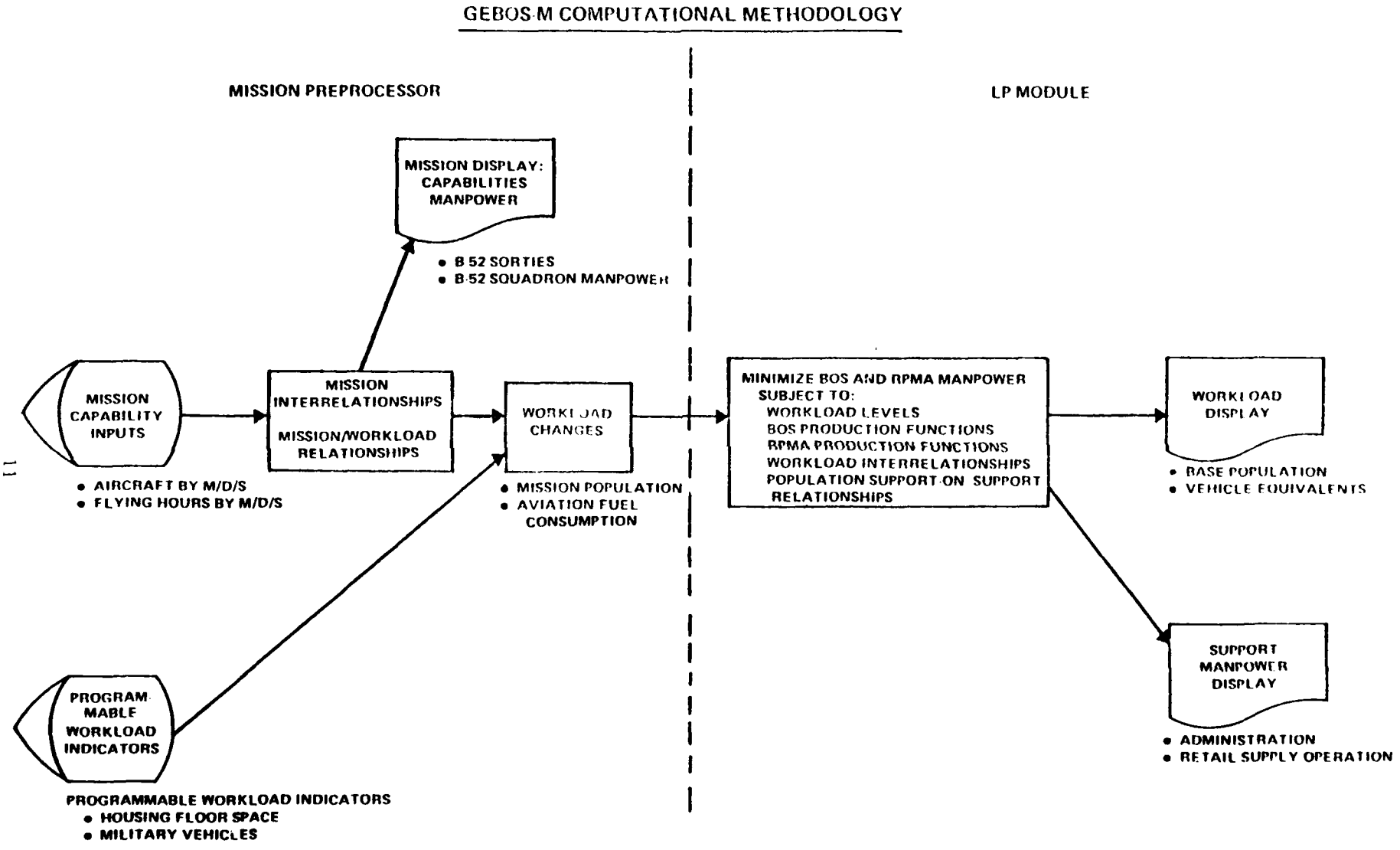


Figure 1. GEBOS-M Computational Methodology Showing Selected Input and Output Variables

SECTION 4
SUMMARY OF ANALYSIS

Following the research methodology described in Section 3, GRC analyzed BOS/RPMA manpower, workload, and mission capability data to isolate reliable and consistent relationships among these factors. These relationships served as the basis for the mission programmable GEBOS-M model.

First phase research and analysis compared BOS and RPMA manpower by functional category with candidate aggregate workload indicators. Functional manpower was the dependent variable, while workload indicators were the explanatory variables. Observations were made by base, with separate equations developed for each command. Functional manpower included officers, airmen, civilians, and contract man-year equivalents (CMYE). The total manpower resources for each functional category were the sum of these four manpower categories.

It should be noted that CMYE resources tend to be under-reported due to the absence of a CMYE reporting requirement on service contracts under $100,000. However, CMYE under-reporting would have a noticeable impact only in selected functions, such as Maintenance of Installation Equipment, Other Personnel Support, and Other Engineering Support. In any case, aggregate under-reporting of BOS and RPMA contract services manpower probably would not exceed 2%, with a commensurately minimal effect upon model output--and then only where selected functions are a part of the model's internal computation processes.

Selected qualitative variables were used to explain manpower variability, in addition to the above quantitative workload indicators. These variables accounted for manpower additions or exclusions associated with a specific base or group of bases. Table 4 lists the manpower/workload equations derived for the RPMA functional categories in SAC, TAC, and ATC. Tables 5 through 7 identify the manpower/workload equations derived for BOS functional categories in the three test commands.

TABLE 4

MANPOWER WORKLOAD EQUATIONS FOR RPMA PROGRAM ELEMENTS

SAC Program Element Code 11894

DOD Functional Category/Code	Explanatory Variables/GEBOS-M Codes: Base Population (C2)	Military Housing Floor Space (V20)	Non-Housing Floor Space (C5)	Missile Bases (V92)	Additives/ Exclusions	Constant	R^2
Maintenance and Repair of Real Property/30	.007854	.01870	.04210	86.26	253.40	99.85	.968
Operation of Utilities/32			.01325		38.31	34.75	.656
Other Engineering Support/33	.007562				158.91	62.49	.820

TAC Program Element Code 27594

DOD Functional Category/Code	Explanatory Variables/GEBOS-M Codes: Base Population (C2)	Military Housing Floor Space (V20)	Non-Housing Floor Space (C5)	Additives/ Exclusions	Constant	R^2
Maintenance and Repair of Real Property/30	.01584	.01758		424.80	178.92	.717
Operation of Utilities/32			.02071		16.86	.631
Other Engineering Support/33	.002717	.002903		94.41	91.38	.696

ATC and USAF Academy Program Element Code 85794

DOD Functional Category/Code	Explanatory Variables/GEBOS-M Codes: Base Population (C2)	Military Housing Floor Space (V20)	Non-Housing Floor Space (C5)	Randolph/ Lackland (D13)	Additives/ Exclusions	Constant	R^2
Maintenance and Repair of Real Property/30		.1166		-243.76		122.43	.891
Operation of Utilities/32	.003836	.01863			-65.54	20.69	.608
Other Engineering Support/33			.003393		72.38	91.11	.509

TABLE 5

MANPOWER/WORKLOAD EQUATIONS FOR [illegible]C BOS PROGRAM ELEMENT CODE 11896

DOD Functional Category/Code	Explanatory Variables/GEBOS-M Codes: Base Population (C2)	Travel Transactions (V29)	Total Item Records (C7)	Aviation Fuel Consumption (V33)	Military Vehicles (V73)	Miles Driven (V76)	Visiting Airmen Beds (V42)	Military Population (C3)	Weighted Rations Served (V72)	Missile Bases (V92)	Additives/ Exclusions	Constant	R^2
Administration/36	.03667	.008306										55.89	.927
Retail Supply Operations/37			.01520	.01188								162.68	.676
Maintenance of Installation Equipment/38					.3734	.01194					107.12	37.74	.909
Other Base Services/39	.02713											148.96	.757
Bachelor Housing Operations/40							.002548			-2.36	12.63	12.44	.567
Morale, Welfare, and Recreation/41								.003061				21.55	.796
Other Personnel Support/42	.002282								.003475	47.68		14.55	.798

TABLE 6

MANPOWER/WORKLOAD EQUATIONS FOR TAC BOS PROGRAM ELEMENT CODE 27596

	Explanatory Variables/GEBOS-M Codes											
DOD Functional Category/Code	Base Population (C2)	Travel Transactions (V29)	Total Item Records (C7)	Aviation Fuel Consumption (V33)	Miles Driven (V76)	Military Vehicles (V73)	Airmen Beds (V42)	Military Population (C3)	Weighted Rations Served (V72)	Additives/ Exclusions	Constant	R^2
Administration/36	.01317									-119.47	198.03	.728
Administration/36*		.005362*								-120.62	247.17	.595
Retail Supply Operations/37			.02508								117.91	.931
Retail Supply Operations/37*				.02721*							245.60	.468
Maintenance of Installation Equipment/38					.01544	.1149					25.05	.648
Other Base Services/39	.03481									11.21	59.53	.740
Bachelor Housing Operations/40							.02013			13.46	10.00	.719
Morale, Welfare, and Recreation/41								.001617		-4.47	28.39	.542
Other Personnel Support/42	.009138								.003516		-12.24	.747

*Supplemental explanatory coefficients for the DOD functional categories indicated. The Base Population coefficient for the Administration functional category and the Total Item Records coefficient for the Retail Supply Operations functional category, shown on this table, are the preferred explanatory variables in their respective functional categories. At the discretion of the GEBOS-M model user, however, the supplemental rather than the preferred explanatory variable may be selected when its application results in a greater manpower resource impact.

TABLE 7

MANPOWER/WORKLOAD EQUATIONS FOR ATC/USAF ACADEMY BOS PROGRAM ELEMENT CODES 85796/85896*

	Explanatory Variables/GEBOS-M Codes												
DOD Functional Category/Code	Base Population (C2)	Travel Trans. (V29)	Total Item Records (C7)	Aviation Fuel Con. (V31)	Military Vehicles (V73)	Miles Driven (V76)	Airmen Beds (V42)	Students Authorized (V91)	Military Population (C3)	Weighted Rations Served (V72)	Additives/ Exclusions	Constant	R^2
Administration/36	.02736	.01537									81.12	105.35	.916
Retail Supply Operations/37			.01249	.01449								142.52	.745
Maintenance of Installation Equipment/38					.2042	.02306					-92.84	26.18	.502
Other Base Services/39	.04154										42.70	42.58	.973
Bachelor Housing Operations/40							.003704		.003789			3.84	.854
Morale, Welfare, and Recreation/41								.002494	.003096		-21.70	23.41	.912
Other Personnel Support/42										.002619		42.21	.970

*USAF Academy data were included with ATC on an experimental basis at the request of AF/MPMZ. Purpose was to isolate common factors in view of common training mission. As a practical matter, essentially the same BOS/RPMA manpower/workload variables apply to the Academy's single station as apply to ATC bases generally.

For Table 4, RPMA program elements and DOD functional categories are listed on the left, while the significant explanatory workload indicators are listed across the center of the page. Tables 5 through 7 are similarly structured for BOS program elements, with each command shown on a separate table. Under the heading "Explanatory Variables," the coefficients listed in each functional workload column indicate the appropriate change in functional manpower that would be required per unit of workload. For example, using Table 4, an increase in base population of 1000 for SAC would increase RPMA functional manpower in the Maintenance and Repair of Real Property category by approximately eight authorizations (.007854 x 1000 = 7.854). Using Table 5, it can be seen that the same population change would increase BOS functional manpower in the Administration category by approximately 37 authorizations (.03667 x 1000 = 36.67). On each table, the coefficients under the "Additives/Exclusions" columns are, effectively, adjustment factors which recognize unique requirements at a selected base or bases identified within the MAJCOMs concerned. On each table, the coefficients under the "constant" columns represent the fixed operating costs of the aggregation of bases within the MAJCOMs concerned before any consideration is given to workload levels by function, or to the unique requirements at selected bases as just discussed. Given appropriate functional workload and base identification data, application of the coefficients shown on Tables 4 through 7 will provide an estimate of total RPMA/BOS manpower requirements for each MAJCOM concerned, by functional category.

On each of Tables 4 through 7, there are listed under the final columns headed "R^2" statistical measures of the explanatory power of the several coefficients shown for each DOD functional category. In each instance, the explanatory power exceeds the 99% statistical confidence level.

Second phase research and analysis linked the primary BOS/RPMA workload indicators with measures of primary mission capability. Primary mission capability measures were analyzed to determine how they impacted on the primary support workload indicators identified in the

first phase research effort. Emphasis was placed upon identification of consistent, reliable, and defensible relationships with support workload indicators, rather than upon purely statistical relationships. Table 8 [illegible] oped for SAC, TAC, and ATC.

In addition to these relationships between mission and workload, several primary workload indicators were found to be of a programmable nature. These were:

- Military housing floor space
- Non-housing floor space
- Military vehicles
- Other mission population

Other support workload indicators were found to be interrelated. Table 9 identifies the support workload interrelationships used in CEBOS-M. For example, SAC travel transactions are determined by base population (CEBOS-M workload indicator C2). The 1.0333 coefficient applied to base population (C2) best estimates the travel transaction workload for any given base population figure. Thus, for example, an increase in base population of 1000 would produce a raw increase of 1.0333 x 1000 = 1033.3 travel transactions. Workload additive or exclusion factors for unique bases are identified by the terms "ADD" or "EXCL" (all cases on Table 9 were exclusions). Base-level constant terms are provided, where appropriate, to bring total workload levels into statistical agreement. R^2 statistics presented in the final column of Table 9 demonstrate statistical significance at the 99% confidence level.

The CEBOS-M model, when used in the mission capability mode, permits the user to introduce any combination of changes in primary mission capability and programmable mission workload indicators. The model then uses the defined BOS and RPMA manpower/workload indicator relationships, BOS/RPMA/mission workload interrelationships, mission capability/workload indicator relationships, and support workload interrelationships to derive the minimum BOS and RPMA manpower necessary to satisfy mission

TABLE 8

MISSION/WORKLOAD RELATIONSHIPS

Weapon System Indicator	Mission Manpower	Total Item Records (C7)	Aviation Fuel Consumption (V33)	Miles Driven (V76)	Students Authorized (V91)	Weighted Rations Served (V72)
		SAC				
B-52D Aircraft	46.43					
B-52D Flying Hours			4.005			
B-52G Aircraft	39.74					
B-52G Flying Hours			3.980			
B-52H Aircraft	43.91					
B-52H Flying Hours			3.325			
B-52 Squadrons	454.70	1984.9				
FB-111A Aircraft	44.78					
FB-111A Flying Hours			1.500			
FB-111 Squadrons	442.45	2008.3				
KC-135A Aircraft	18.70	1696.0				
KC-135A Flying Hours			2.330			
KC-135Q Aircraft	21.20					
KC-135Q Flying Hours			2.180			
KC-135 Squadrons	69.09					
E-4A Aircraft	117.33					
E-4A Flying Hours			4.070			
E-4A Squadrons		3919.7				

TABLE 8 (Continued)

Weapon System Indicator	Mission Manpower	Total Item Records (C7)	Aviation Fuel Consumption (V33)	Miles Driven (V76)	Students Authorized (V91)	Weighted Rations Served (V72)
LGM-25 Missiles (Titan)	57.75			89.50		
LGM-25 Squadrons		975.0				
LGM-30 Missiles (Minuteman)	10.46			24.74		
LGM-30 Squadrons	4.00	1153.3				
		TAC				
A-7D Aircraft	18.19					
A-7D Flying Hours			.685	.092		
A-7 Squadrons	375.04					
A-10A Aircraft	14.73					
A-10A Flying Hours			.515	.107		
A-10 Squadrons	375.04	400.5				
F-4C Aircraft	22.68					
F-4C Flying Hours			1.555	.073		
F-4D Aircraft	22.68					
F-4D Flying Hours			1.535	.070		
F-4E Aircraft	22.68					
F-4E Flying Hours			1.570	.073		
F-4 Squadrons	375.04	1398.5				
RF-4C Aircraft	18.96					
RF-4C Flying Hours			1.335	.090		

TABLE 8 (Continued)

Weapon System Indicator	Mission Manpower	Total Item Records (C7)	Aviation Fuel Consumption (V33)	Miles Driven (V76)	Students Authorized (V91)	Weighted Rations Served (V72)
RF-4 Squadrons	375.04	2990.8				
F-15A Aircraft	39.99					
F-15A Flying Hours			1.395	.075		
F-15B Aircraft	39.99					
F-15B Flying Hours			1.395	.076		
F-15 Squadrons	375.04	3054.6				
F-105F/G Aircraft	4.82					
F-105F/G Flying Hours			1.285	.067		
F-105 Squadrons	375.04					
F-5E Aircraft	6.41					
F-5E Flying Hours			.575	.053		
F-5 Squadrons	375.04					
F-111A/D Aircraft	27.60					
F-111A/D Flying Hours			1.500	.131		
F-111 Squadrons	375.04	1544.0				
EC-135P Aircraft	110.67					
EC-135P Flying Hours			1.950	.207		
		ATC				
T-37B Aircraft	3.82				2.16	47.87
T-37B Flying Hours			.180			

TABLE 8 (Continued)

Weapon System Indicator	Mission Manpower	Total Item Records (C7)	Aviation Fuel Consumption (V33)	Miles Driven (V76)	Students Authorize (V91)	Weighted Rations Served (V72)
T-38A Aircraft	3.82				2.16	47.87
T-38A Flying Hours			.390			
T-43A Aircraft	36.88				63.50	1407.16
T-43A Flying Hours			.850			
Recruit Training Workload	.19	.469			1.00	22.16
Technician Training Workload	.45	.469			1.00	22.16
Crypto/Intelligence Training Workload	1.53	.469			1.00	22.16
Cadet Training Workload	1.02	.469			1.00	22.16
Professional Education Training Workload	.89	.469			1.00	22.16
Flight Training Squadron	446.57	1344.0				
Pilot Training Workload	1.77	.469	72.72		1.00	22.16
Navigator Training Workload	.58	.469	10.70		1.00	22.16

TABLE 9

WORKLOAD INTERRELATIONSHIPS

Workload Indicators/ GEBOS-M Codes	Explanatory Interrelationship Equation	R^2
SAC		
Travel Transactions (V29)	= 1.0333(C2) - 1176.12	.599
Miles Driven (V76)	= 0.1883(C2) + 4122.5(V92) - 2510.8(EXCL)	.804
Military Population (C3)	= 0.8277(C2)	.892
Airmen Population (V16)	= 0.8330(C3)	.981
Weighted Rations Served (V72)	= 3.1065(V16) - 6845.0(EXCL) + 5684.5	.598
Visiting Airmen Beds (V42)	= 0.00469(V16) - 120.4(EXCL) + 101.8	.380
TAC		
Military Population (C3)	= 0.8340(C2)	.977
Weighted Rations Served (V72)	= 3.4134(V16) - 2517.6(EXCL) + 5027.4	.707
Visiting Airmen Beds (V42)	= 0.0234(V16) - 109.9(EXCL) + 35.2	.371
Airmen Population (V16)	= 0.8614(C3)	.989
ATC		
Travel Transactions (V29)	= 1.0468(C2) - 171.7	.378
Military Population (C3)	= 0.5774(C2)	.867
Weighted Rations Served (V72)	=22.1644(V91) - 1862.3	.904
Miles Driven (V76)	= 0.2160(C2) + 375.2	.474
Visiting Airmen Beds (V42)	= 0.2326(V16) - 634.7(EXCL) + 158.0	.856
Airmen Population (V16)	= 0.7642(C3)	.961

requirements. Air Force manpower managers thus acquire a greatly improved capability to quantify support requirements for various mission alternatives and conclusively demonstrate BOS/RPMA support requirements

Table 10 provides two illustrative examples of the types of support manpower changes estimated by the GEBOS-M model for primary mission changes. In the first example, a squadron of 17 B-52Hs is added to increment forces at an existing SAC base. Annual flying hours per aircraft are also supplied. The model then uses two modules to perform its computations, a mission preprocessor and a linear programming module. Based upon the indicators identified in Table 2, the mission preprocessor estimates changes to manpower, total flying hours, and sorties. Then, the mission preprocessor estimates changes to BOS workload according to the relationships identified in Table 8 between mission capability indicators and support workload indicators. These workload changes are transferred into the linear programming module. The linear programming model was previously developed by GRC.[1] The linear programming module uses the BOS manpower/workload equations in Table 5, workload interrelationships in Table 9, and an equation relating support and mission manpower to total base population to produce estimates of the mission changes. The second example in Table 10 illustrates changes generated by a one squadron, 18 F-4D aircraft, 240 flying hours/aircraft change in TAC. The final example illustrates changes generated by a 100-pilot training workload change in ATC.

These examples illustrate the ability of the model to compute BOS requirements tailored to specific mission requirements. Different types of aircraft, missiles, and training workloads will produce different support manpower requirements. GEBOS-M can also be used in an explanatory mode to compute the workload capabilities of different levels of support manpower. GEBOS-M produces mission capability, support workload, and

[1] Edward J. Schmitz, et al., Development of a Generalized Explanatory Base Operating Support (GEBOS) Model, 1112-01-79-CR, January 1980.

TABLE 10

ILLUSTRATIVE EXAMPLES OF MODEL COMPUTATIONS

User Input	Mission Capability Changes	Workload Changes	BOS Manpower Changes
Example of a Mission Change to SAC			
17 B-52Hs	6936 Flying Hours	1397 Base Population	63.2 Administration
408 Flying Hours/ Aircraft	978 Sorties	1444 Travel Transactions	53.0 Retail Supply
1 Squadron	1085 B-52 Squadron Manpower	1904 Total Item Records	3.1 Maintenance of Installation Equipment
	116 SRAM Manpower	1921 Aviation Fuel Consumption	37.9 Other Base Services
		263 Miles Driven	0.0 Bachelor Housing
		5 Visiting Airmen Beds	3.5 Morale, Welfare, and Recreation
		1156 Military Population	13.6 Other Personnel Support
		2993 Weighted Rations Served	174.3 Total
Example of a Mission Change to TAC			
18 F-4Ds*	4320 Flying Hours	899 Base Population	11.8 Administration
240 Flying Hours/ Aircraft	3434 Sorties	2207 Travel Transactions	35.1 Retail Supply
1 Squadron	783 Squadron Manpower	1399 Total Item Records	3.0 Maintenance of Installation Equipment
		553 Aviation Fuel Consumption	31.3 Other Base Services
		192 Miles Driven	0.3 Bachelor Housing
		15 Visiting Airmen Beds	1.2 Morale, Welfare, and Recreation
		749 Military Population	16.0 Other Personnel Support
		2204 Weighted Rations Served	98.7 Total

TABLE 10 (Continued)

User Input	Mission Capability Changes	Workload Changes	BOS Manpow	Changes
	Example of a Mission Change to ATC			
100 Pilot Training Workload	22 T-37Bs	220 Base Population	9.5 Administr	ion
	23 T-38As	230 Travel Transactions	9.4 Retail S	ly
	13,240 T-37B Flying Hours	47 Total Item Records	1.1 Maintenar	of Instal-
	12,530 T-38A Flying Hours	606 Aviation Fuel Consumption	Ec	ment
	10,600 T-37B Sorties		9.1 Other Bas	Services
	10,120 T-38A Sorties	48 Miles Driven	0.6 Bachelor	using
	155 Undergraduate Pilot Training Manpower	5 Visiting Airmen Beds	0.7 Morale,	are, and Recreatio
		131 Military Population		
	21 Other Flight Training Manpower	4432 Weighted Rations Served	11.6 Other Per	nnel Support
			42.0 Total	

support manpower estimates in terms of both a fiscal year baseline and in increments to the baseline. These capabilities provide Air Force manpower planners with greatly enhanced support requirements insight for various mission alternatives, and the ability to demonstrate BOS/RPMA support requirements expressed in functional category detail for alternative mission force structure levels.

SECTION 5

CONCLUSIONS AND RECOMMENDATIONS

GRC's research has demonstrated in scientific and logical terms, of providing to Air Force manpower managers an automated capability to demonstrate in functional category detail the BOS/RPMA manpower/workload impact of changes in primary mission capabilities. The outputs of the GEBOS-M model for the test commands (SAC, TAC, and ATC) at alternative mission capability levels have undergone initial validation through comparison to the results of recent actual primary mission force structure changes.

Based upon these outcomes, we recommend:

- Final validation of GEBOS-M outputs through fully documented GEBOS-M model exercises, with Air Staff, AFMEA, and MAJCOM participation.
- Upon successful completion of the final validation exercises, the extension of the GEBOS-M model to provide an Air Force-wide capability.

Final validation exercises with the broad participation of Air Force manpower managers at Air Staff and field level will assure:

- An acid test of the programmatic consistency and reliability of model outputs, as well as the opportunity to update the data base and fine tune data interrelationships.
- The support of GEBOS-M by Air Force manpower management authorities, through their familiarization with model operation and capabilities, as a prerequisite to its extension Air Force-wide and its employment by the Air Staff as a primary manpower management tool.

In conducting final validation exercises, participants should be afforded every opportunity to focus upon the evaluation and fine tuning

of model outputs in the light of their uniquely specialized manpower management insights within their own areas of functional expertise. Every element of the final validation exercises should be fully documented. The documented results should be collected and fully evaluated by a central exercise management authority fully qualified in the intricacies of model construction/operation, such that maximum benefit is derived from lessons learned at individual locations/commands through across-command applications.

Upon completion of final model validation, the task of extending GEBOS-M Air Force-wide should begin. Execution will require collection of command-peculiar mission capability/workload data and BOS/RPMA manpower/workload indicator data for inclusion in the existing data base. Since the bulk of these data are already collected using automated processes, expansion of the GEBOS-M data base to support Air Force-wide application can be readily accomplished. Similarly, provisions for regularized periodic data base update can be readily established. Completion of this final phase of the model development effort will:

- Improve GEBOS-M estimation capabilities by allowing complete analysis of tenant unit manpower/workloads, in turn allowing more precise assessment of tenant unit impacts upon base workload.
- Assure that across-command interrelationships are fully taken into account in the model estimation process.
  - A manpower/workload/force structure change in one command can directly impact the manpower/workload/force structure posture of other commands.
  - For example, a weapons system increment/decrement in SAC can directly influence ATC training workload increments/decrements.
- Expand GEBOS-M estimation capabilities across time, converting the model from a single year estimating capability to a

dynamic multi-year forecasting tool covering the Five Year Defense Program (FYDP) period.

- A programmatic FYDP capability will also allow full coverage of manpower/workload leads and lags.
- For example, the ATC training pipeline changes referenced above might need to be initiated at least a year in advance of the SAC force structure changes they are designed to support.

- Provide Air Staff and other top manpower managers with the:
  - Rapid reaction capability to timely respond to day-to-day management needs and challenges
  - Ability to most effectively justify and define Air Force manpower needs through automated access to manpower/workload impact data in functional category detail for the universe of alternative mission force structures.

APPENDIX A

GLOSSARY

Aviation Fuel Consumption: The average monthly aviation fuel consumed in thousands of gallons.

Base Population: The sum of total base officer authorizations, total base airmen authorizations, total base civilian authorizations, and total base contract man-year equivalents.

Miles Driven: Annual miles driven in thousands of miles.

Military Housing Floor Space: Square feet of floor space associated with military family housing units, in thousands of square feet.

Military Population: The sum of total base officer authorizations and total base airmen authorizations.

Military Vehicles: The total number of K-type vehicles (trucks, ambulances, tractors, and trailers).

Missile Base: A base containing Minuteman or Titan missiles.

Non-Housing Floor Space: Total base floor space, in thousands of square feet, minus military housing floor space.

Students Authorized: Total number of students authorized.

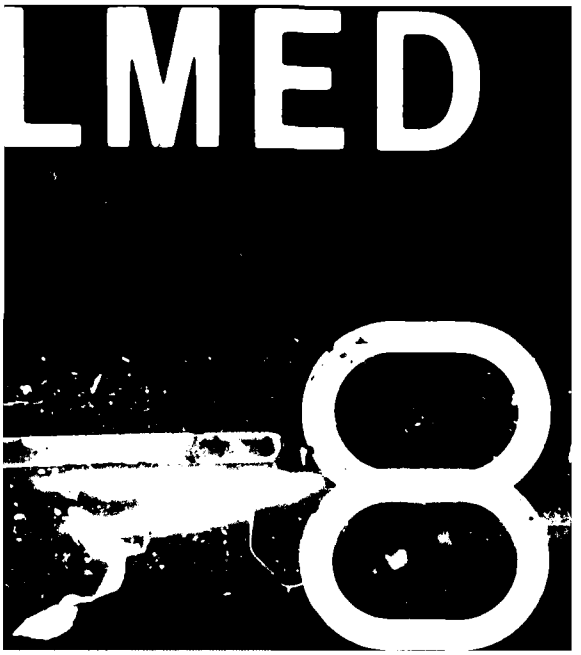
Total Item Records: The average monthly sum of equipment and supply item records.

Training Workload: Average daily student training workload, from the Military Manpower Training Report.

Travel Transactions: Average monthly travel transactions processed under functional account code 1514.

Visiting Airmen Beds: Number of visiting airmen beds.

Weighted Rations Served: Average monthly weighted rations served.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