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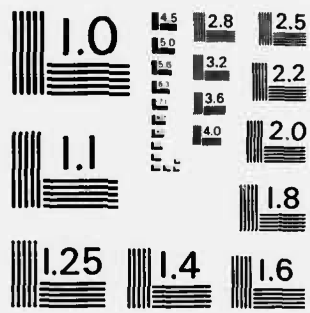

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A MODEL FOR ESTIMATING BASE OPERATING SUPPORT (BOS) REQUIRED TO SUPPORT NAVY TRAINING ACTIVITIES

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The objective of this effort was to develop manpower-estimating equations to forecast aggregate manpower requirements within the base operating support (BOS) sector of Navy training activities. Training activities were organized into training "complexes" according to like geographic location. Data on the physical size and population supported by the training complex were matched with measures of student workload; that is, workload imposed by mission-related forces resident at the complex.

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Multiple regression analysis produced a two-part statistical model for total BOS-training manpower. The real property maintenance component of the model is driven by facility size; and the other base services component, by student workload (tenant population at naval air stations). Therefore, the resulting model separates the generally constant manpower required to maintain an activity of a certain size from the BOS requirements generated by the primary base mission.

FOREWORD

This research and development effort was conducted in support of Navy decision coordinating paper Z1186-PN (Fleet Demand for Support Manpower), subproject Z1186-PN.06 (Forecasting Long-range Manpower Requirements), and was sponsored by the Deputy Chief of Naval Operations (Manpower, Personnel, and Training) (DCNO(MPT)). The objective of this subproject is to develop long-range, aggregate manpower planning models to forecast Navy requirements for officer, enlisted, and civilian manpower.

This report is the second in a series relating to forecasting long-range aggregate support manpower requirements. The first (NPRDC TR 82-29) documented the development of manpower estimating equations for two types of base operating support (BOS) activities--naval stations and naval air stations. This report contains the results of an effort to derive equations for forecasting BOS manpower requirements for the Navy's training establishment. In addition to the technical considerations leading to the final model specifications, a detailed description of the data collection and preparation effort is included.

The BOS-training manpower forecasting model has potential application at the claimant and CNO programming levels. Currently, it can be used by DCNO(MPT), Programming Development and Coordination Branch (OP-120), and the Chief of Naval Education and Training to evaluate Navy BOS manpower required to support projected student workload.

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SUMMARY

Problem

The Navy does not have an established analytic procedure for estimating total base operating support (BOS) manpower required to support training programs. This weakness has contributed to budget cuts to Navy BOS programs that, in turn, could degrade the naval training establishment's capability to support the missions of the fleet.

Objective

The goal of this effort was to develop an analytic model containing specific estimating equations that relate Navy BOS-training manpower requirements to aggregate indicators of training workload. The analysis placed special emphasis on the impact of changing student loads upon BOS manpower requirements.

Approach

Data were collected on historic BOS-training manpower, student workload, facility size and age, and tenant population. These data were assembled into a data base organized by geographic location for 4 years--FYs 78-81. (Before FY78, the Navy's accounting system did not separate BOS resources from mission resources.) Sources for other data were identified, evaluated, and matched to the historic BOS-training manpower data (i.e., student workload, facility size/age, tenant population). These data were then analyzed using multiple regression and exploratory data analysis techniques, with emphasis on deriving relationships that were both conceptually sound and statistically valid.

Results

Based on the 4-year profile of BOS-training manpower and workload indicators for training installations, it was found that total BOS-training manpower was not related to facility size, tenant, and student workload data. A suitable model was formed only after separating total BOS-training manpower into two components--one for real property maintenance (related to facility size) and one for other base services (related to student workload and, for naval air training stations, tenant population). This two-part model is plausible in that it clearly separates the generally constant manpower required to maintain a base of a given size from the BOS requirements generated by the primary base mission.

Conclusions

BOS manpower that supports training is driven by the workload imposed by the presence of students and other shore tenants. The fact that this relationship has been quantified should provide Navy manpower planners with a basis for justifying their requests for BOS-training resources.

Recommendations

The model should be implemented in an interactive computing environment to allow "hands-on" access by Navy planners. Some future work may be required in relating a portion of the tenant population (instructors, technicians, and other providers of direct training support) to student workload. A more ambitious challenge would be to link these results to existing Navy factors that relate student workload to future fleet requirements. This would allow BOS-training manpower requirements to be tied to planned force levels.

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INTRODUCTION

Problem

The problem of forecasting the manpower resources required to support planned force levels has received increasing visibility throughout the Navy's planning and programming organizations. The problem is heightened with the movement toward a 600 ship/15 battle group navy. The emphasis on procurement for new ships, aircraft, and weapon systems, in conjunction with the President's otherwise austere budget policies, has led to a reduction in resources allocated to support programs. Paradoxically, these reductions have occurred at the same time when the forces to be supported are on an increase and their readiness is being criticized. Many Navy planners feel that these reductions have occurred because of the inability to quantify, during the planning and programming phases of the Planning, Programming, and Budgeting System (PPBS) cycle, the relationship between the projected size of the fleet and fleet support requirements.

There is a definite need for improved analytical methods, models, and data bases to support long-range planning. The models must be able to identify specifically the relationship between support manpower requirements and the force levels being supported. Forecasting base operating support (BOS) manpower requirements has been especially difficult because of the diverse functions and indirect fleet support missions of BOS activities. Hudak, King, and Rhodes (1982), who addressed this problem as it applies to naval stations (NAVSTAs) and naval air stations (NASs), demonstrated that the manpower requirements of these major BOS installations could be related to the demand for services imposed by both the resident forces and the shore-based "tenant" population. This effort extends the analysis of the previous effort to cover the BOS manpower that supports the Navy's training activities. The need for such a forecasting methodology has been confirmed by the Deputy Chief of Naval Operations (Manpower, Personnel, and Training (DCNO(MPT)) and the Chief of Naval Education and Training (CNET)(Code N-61).

Objective

The immediate goal of this effort was to develop methods of forecasting the BOS manpower required to support major training activities. The forecasting methodology had to be formulated such that it could substantiate the need for BOS training manpower authorizations based on programmed force levels. BOS training manpower requirements are one step removed from force levels in the sense that force levels drive the training plan, which, in turn, drives BOS requirements. While the objective was to define and analyze only the latter half of this serial relationship, it was imperative that the resulting model be coupled to existing forecasting models that relate future forces to training plans.

Background

DCNO(MPT) (OP-01) is responsible for determining the manpower requirements needed to support projected force levels. In particular, the Total Force Programming Division (OP-12), acting as MPT resource and assessment sponsor, is responsible for programming required resources; and the Program Development and Coordination Branch (OP-120), for determining the requirements for various types of training (recruit, specialized, officer acquisition, professional development, and flight). OP-120 recommendations on manpower requirements are included in the Program Objectives Memorandum (POM) and strongly influence the formulation of the Navy's budget requests. Ultimately, this process results in the end strength authorizations approved by Congress.

During the course of the PPBS process, OP-120 periodically receives input and feasibility analysis from CNET and the Chief of Naval Technical Training (CNTECHTRA).

OP-120 currently uses the skill accession training (SKAT) model to develop training-related requirements based upon projected force levels and authorized accession levels. Output from SKAT is input to the training resource model (TRM), which computes the costs associated with the training requirements. Although TRM estimates the costs associated with indirect support (including BOS), these estimates are based upon the last observable aggregate (across all activities) student workload-to-support ratio and do not reflect the impact of workload changes over time.

OP-120 also provides the necessary data for the Navy input to the military manpower training report (MMTR), an annual submission of the Secretary of Defense to Congress. The FY 1980 MMTR (p. IX-9) acknowledged that the military services are not able to track "training-attributable" indirect support in their accounting systems as these systems do not adequately distinquish training from nontraining activities at major training installations.

The Navy has begun to address the problem of separating "mission" resources from support resources in recent years. Beginning in FY 1978, the Office of the Navy Comptroller (NAVCOMPT) has gradually changed the Navy's program elements (PEs) so that BOS manpower and fiscal resources could be separately identified in the Navy cost information system (NCIS). This has been done by creating and applying the activity/sub-activity group nomenclature, a more general informational structure that accounts for resources functionally throughout the Navy.[1]

APPROACH

Scope of the Model

Table 1 shows the Navy PEs containing BOS-training manpower and their FY 1981 Navy end strengths, as shown in the NCIS data base.[2] The end strengths, which constitute the manpower pool to be modelled, are those needed to support training activities at naval training centers (NTCs), fleet training centers (FLETRACENs), naval technical training centers (NAVTECHTRACENs), naval air technical training centers (NATTCs), naval air training stations, personnel support activities (PERSUPPACTs), naval administration commands (NAVADMINCOMs), and miscellaneous activities supporting individual schools.[3] The BOS manpower at a given training complex may reside under the

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[1]CNO memorandum POM 84-13, ser. 901/327153 of 14 January 1982; subj: Data entry requirements for POM-84.

[2]Because of the large number of tables in this section relative to the amount of text, the tables are placed at the end of the section, commencing on page 7.

[3]While the objective was to model all of the manpower included in the program elements listed in Table 1, the BOS manpower at five activities, amounting to a combined total FY81 end strength of 50, was excluded because of missing or misleading data. These five activities were (1) the Diving and Salvage School, Washington, DC, which moved to Panama City, Florida, (2) the NTC at Bainbridge, MD., which closed, (3) the submarine complex at Bangor, Washington, which is under development, (4) the BOS at Port Hueneme, California, which is provided by a nontraining host, and (5) the Nuclear Power Training Unit in Windsor, Connecticut, which had no workload data and insignificant manpower.

command of several individual supporting activities. Existing information systems do not accurately track over time either the manpower or the workload at each activity, partly because of the recent changes in the accounting system alluded to previously. For modelling purposes, it was decided to aggregate these supporting activities by location. This approach is consistent with the level of detail required by OP-120/CNET.

Conceptual Model

Generalizing from the earlier analysis (Hudak et al., 1982) it was believed that the BOS training manpower should be functionally related to training workload, facility size, and population supported. Indicators for these three factors were collected and aggregated, where necessary, by geographic location. Since facility size is generally constant at a particular location, it was expected to drive that portion of the BOS requirement associated with operating the complex independent of mission (i.e., training) requirements. The student workload indicators and, to a lesser degree, the tenant population represent the dynamic variables that, in turn, are conceptually related to force levels.

A key measure of training load is the student workload, as defined in accordance with CNET and DoD standards in the FY81 MMTR (Appendix A). This is calculated at the course-activity level from the planned number of graduates, course lengths, and attrition patterns, and approximates the average-on-board. In addition to support of Navy military personnel, the BOS workload at Navy training complexes is generated by other service personnel, civilians, and foreign personnel. (The student workload measure includes these non-Navy personnel.) Furthermore, it is used by CNET and OP-01 for programming purposes and for reporting to Congress in the MMTR. Other measures of student activity, such as the number of courses available, total course days, maximum capacity, etc., were collected and considered in the statistical analysis as additional or alternative drivers of BOS requirements.

Since Hudak et al. found that public work centers (PWCs) contributed significantly in supplying BOS services, their contributions were considered in evaluating the BOS training manpower in areas where PWCs are located (i.e., San Diego, Great Lakes, Pensacola, Norfolk, Pearl Harbor, and San Francisco). Another concern was the presence of nontraining providers of BOS services at certain locations. Because it was not known how much support these nontraining hosts provide to training activities, it was conceptually difficult to match manpower to workload. Fortunately, it appears that this problem was solved by separating BOS end strength into the real property maintenance (RPMA) and other base services components (discussed on page 20).

Data Collection

The Navy facilities assets data base (NFADB) provided information on facility size and age. While the NFADB contains information on property as well as on Navy-owned buildings or structures, Hudak et al. (1982) found that the square footage of building space represents the best measure of overall facility size. Each NFADB building record contains a data element, called the RPMA UIC, which is the unit identification code (UIC) of the activity responsible for providing (either directly or by purchasing services from PWC or private contractors) the real property and maintenance (RPMA) services. All records that have, as their RPMA UIC, a BOS host that supported a training activity were extracted from the NFADB. Total building space was found by summing over all such records at a given location. Other NFADB data elements were used to identify the parts of total building area considered to be "inadequate" or "substandard." In addition, the amount of building area used for unaccompanied personnel or family housing was calculated. It was felt that a greater share of housing space or inadequate facilities might be indicative of a greater BOS workload.

Historical workload data were collected from two CNET sources--the Navy integrated training resources administration system (NITRAS), which contains the workload data for recruit and specialized training; and the cost accounting system maintained by N-62, which contains the necessary information for professional development, officer acquisition, and flight training. Both sources provided the data by student UIC, which was then matched by location to the BOS end strength from the NCIS.

To avoid possible inconsistencies resulting from using two separate information systems, the information previously prepared as part of the Navy's submissions to the annual MMTR was selected as a preferred source. This set of data represents the planned workload by location for Navy installations; in instances where comparisons were possible, these data showed a strong correlation (.98) with the actual workload reported in NITRAS. Moreover, the MMTR data were available over the entire FY 1978-FY 1981 period of interest, whereas NITRAS data were available only since FY 1979.

In addition to workload data, NITRAS is also the source for other course-related information, such as number of courses, convening frequencies, and maximum capacity for each course by training activity. These indicators were studied with respect to their influence on BOS requirements. Also, the PWC survey previously conducted by MATHTECH with the cooperation of the Naval Facilities Engineering Command (NAVFAC) was used to determine the PWC support received at the major training complexes (see Hudak et al., 1982, p. 8).

CNET also provided the host-tenant lists necessary for combining the BOS end-strength and workload data into a comprehensive data base organized by location. This list was modified in several respects. Some training activities that are tenants of nontraining hosts (e.g., the Navy Manpower Training Detachment (NAMTRADET), Lemoore, a tenant of NAS, Lemoore) were dropped since they have no identifiable BOS manpower within the scope of the model. However, in other instances, training activities were tenants of nontraining hosts but contained their own BOS manpower. For example, the BOS activity in support of the Naval Amphibious School (NAVPHIBSCOL) activity at Little Creek is considered to be a tenant of the Naval Amphibious Base (NAVPHIBASE). This type of BOS-training activity was considered to be the host for purposes of the model. As mentioned earlier, these locations were of concern because it was not possible to account for BOS support received from the nontraining host (i.e., NAVPHIBASE).

In addition, it was discovered that, in a number of instances, the mission end strength associated with a training host was omitted from the host-tenant lists. For example, the Naval Education and Training Center (NETC), Newport, has three distinct UICs: 62661, which provides the BOS-training manpower, and 42115 and 42130, which include direct training support. The latter two UICs were not included in the CNET lists; even though they should have been considered as tenants to the BOS "host" 62661. A geographic location variable that was available in the NCIS data base aided in the tenant compilation process. Also, a host-tenant list included in CNO's Domestic Base Factors Report (1982) was used as a cross check in assembling the final host-tenant list. This list was merged with the NCIS data, resulting in the tenant population variable. Students were excluded from the tenant population data because their impact was already accounted for via student workload measures.

Data Preparation

The BOS-training manpower to be modelled was assembled and organized by location from the FY 1981 NCIS tape. The resulting data set, which covers FY 1978-FY 1981, is shown in Table 2. During the time frame of interest, the NCIS reflected shifts of manpower among activities of a single complex, thereby showing meaningless relationships at the activity level. For example, for the Orlando complex, personnel have been shifted in the accounting system from the NTC to NAVADMINCOM and PERSUPPACT. Thus, it is the location total that is meaningful, not the activity detail. In fact, since the NTCs contained "mission" related personnel in addition to BOS prior to FY78, it was not meaningful to extend the data base before that year. The activity/subactivity group detail for FY81 proved useful in that it provided a mechanism for separating the RPMA support from other BOS functions. This led to the two-equation model, which is discussed on page 20.

The actual data that emerged in the eventual model are documented here for review and reference. Table 3 presents the final host-tenant list by location; Table 4, student workload and tenant population end strengths by location; and Table 5, facility size and age data by location.

Analysis

The final data base consists of 108 observations for 27 locations (one observation for years FY78-81). The most general multivariate linear model for this type of cross-sectional data is of the form:

$$BOSMP_{it} = a_{it} + \sum_{k=1}^{N} \left(b_{kit} \cdot X_{kit}\right) + e_{it},$$

where $i = 1, 2, \ldots 27$ represents the location index,
$t = 1, 2, 3, 4$ represents the year index, and
$X_1, X_2, \ldots X_N$ corresponds to the set of independent variables.

In this notation, $BOSMP_{it}$ represents the BOS end strength at location i in year t, X_{kit} corresponds to the value of X_k for that location and year, and e_{it} is the random error term associated with location i and time t. The standard assumptions concerning the e_{it}'s are that they have (1) an expected value of zero, (2) a multivariate normal distribution and are independent of each other, and (3) the same constant variance. The model is said to be heteroscedastic if the constant variance assumption is not valid and autocorrelated if the errors are not mutually independent. Some statistical properties of the least-squares parameter estimates are weakened in the presence of heteroscedasticity or autocorrelation. While the estimates are still unbiased, they no longer have minimum variance (within the class of unbiased estimates). Under these conditions, ordinary least squares underestimates the standard error of the estimate.

These considerations are less relevant in view of the goal of using this model at an aggregate, rather than at a location-specific, level. Undoubtedly, the BOS requirements are influenced by location-specific factors (size of retiree population, proximity to medical facilities, climate, etc.), which are beyond the scope of this effort. Compensating for these factors by allowing each location to have its own intercept dampens the overall influence of the independent variable and is intuitively unappealing for an aggregate model. Conceptually, the problem created by the diversity in size and function of the training complexes is addressed by considering dummy variables for each type of training. In this way, for example, the differences between the BOS requirements for air stations resulting from the presence of flight operations and the requirements for smaller specialized training installations can be accommodated. For reference, the locations are categorized by type of training in Table 6.

Because the BOS-training manpower requirements should not inherently vary in a systematic way with time, the conceptual model should not call for year-dependent estimates of parameters. As the results will show, the data substantiates the time independence of the model.

These considerations reduce the general model to the simple form:

$$BOSMP_i = a + \sum_{i=1}^{N} b_{ki} \cdot X_{ki}.$$

Although this representation is linear in terms of the coefficients, the X_k's may in fact be nonlinear transformations of the independent variables.

Table 7 shows the variables that were calculated at each complex to represent the three factors contributing to BOS manpower requirements: (1) facility size and age, (2) student load, and (3) tenant population supported. The overall strategy was to obtain the combination of variables from Table 7 that is conceptually, as well as statistically, a valid "driver" of BOS requirements. It is especially important to separate the nearly constant requirement generated by the size of the training complex from that portion of BOS requirements driven by the student and other tenant populations. As the final results show, this consideration led to the breakdown of BOS requirements into two components that are modelled separately.

Table 1

FY81 BOS End Strength for Training Program Elements (PEs)

PE	Title	FY 81 End Strengths Officer	Enlisted	Civilian	Total
85794N	Real property maintenance--training support installations	51	341	2310	2702
85795N	Base communications--training	7	123	59	189
85796N	Base operations--training	551	5616	4211	10378
85894N	Real property maintenance--service academy	0	0	460	460
85896N	Base operations--service academy	23	42	338	403
TOTAL		632	6122	7378	14132

Table 2

BOS End Strength by Location and UIC Title

Location	UIC	UIC Title	FY78	FY79	FY80	FY81
Annapolis, MD	B0016100	USNA Annapolis MD	0	0	0	23
	B3328400	NAVSTA Annapolis MD/BCT	8	7	6	0
	B3328500	USNA Annapolis MD/BCT	1	0	1	0
	B4208200	USNA Annapolis MD/Base OPS	784	744	736	720
	B4253400	USNA Laundry SVC	92	86	89	78
	B6222600	NAVSTA Annapolis MD	0	0	0	6
	B6661500	CBU 403	29	39	42	43
Total			914	876	874	870
Athens, GA	B6274100	NAVSCSCOL Athens GA	87	70	60	66
Chase Fld, TX	B3327500	NAS Chase Field TX/BCT	14	13	11	0
	B6037600	NAS Chase Field Texas	509	514	514	493
Total			523	527	525	493
Charleston, SC	B6260300	FLETRACEN Charleston SC	14	23	17	13
	B6332200	FLEBALMISUBTRACEN Chstn SC	24	28	30	27
Total			38	51	47	40
Corpus Christi, TX	B0021600	NAS Corpus Christi Tex	1026	958	1150	936
	B3327600	NAS Corpus Christi TX/BCT	42	41	38	13
	B6662900	CBU 407	47	57	56	54
	B6861200	PERSUPPACT Corpus Christi	0	0	0	244
Total			1115	1056	1244	1247
Dam Neck, VA	B0028100	FAAWTRACEN VA Beach VA	424	297	323	326
	B4314800	NAVGMSCOL Dam Neck VA/BOS	0	0	34	5
	B6461900	NAVGMSCOL Dam Neck VA	0	0	0	24
Total			424	297	357	355
Great Lakes, IL	B0012800	NAVADMINCOM NTC Great Lakes	538	535	780	792
	B0021000	NTC Great Lakes ILL	430	368	42	61
	B0580A00	NAVSERVSCOLCOM Great Lks Ill	0	0	0	48
	B4210600	NTC Great Lakes/BCT	1	1	1	1
	B6617600	TRANSITPERSU ADCM Great Lks	70	81	64	59
	B6644600	CBU 401 PWC NTC Great Lakes	32	35	34	36
	B6859800	PERSUPPACT Great Lakes	0	0	258	328
Total			1071	1020	1179	1325
Gulfport, MS	B4326200	NAVCONSTRACEN Gulfport/BOS	0	0	21	0
	B6597100	NAVCONSTRACEN Gulfport MS	0	0	0	12
Total			0	0	21	12
Idaho Falls, ID	B4314700	NUCPWRTRAU-BOS	0	16	6	0
	B6298500	NAVNUPWRTRAU Idaho Falls Idaho	0	0	0	5
	B6519800	NAVADMINU Idaho Falls Idaho	42	43	36	41
Total			42	59	42	46
Indian Head, MD	B6264000	NAVSCOLEOD Indian Head MD	16	85	11	9
Kingsville, TX	B3327900	NAS Kingsville TX/BCT	16	14	0	0
	B6024100	NAS Kingsville Texas	456	495	474	477
Total			472	509	474	477

Note. Data includes total active duty officer and enlisted and U.S. civilians. Obtained form NCIS data base.

Table 2 (Continued)

Location	UIC	UIC Title	FY78	FY79	FY80	FY81
Lakehurst, NJ	B6309400	NATTC Lakehurst NJ	38	35	23	27
Little Creek, VA	B0618A00	NAVSCOL Music Little Creek	2	2	2	1
	B6302100	NAVPHIBSCOL Little Creek VA	20	68	15	16
Total			22	70	17	17
Mayport, FL	B1015100	FLETRACEN Mayport FLA	5	20	7	4
Memphis, TN	B0063900	NAS Memphis	1056	1023	961	950
	B3327100	NAS Memphis/BCT	25	26	23	6
	B3557700	MIISA Dept Memphis	0	13	102	87
	B4306000	HRMS Memphis BOS	0	0	8	2
	B6309300	NATTC Memphis Tenn	96	341	108	78
	B6311500	NAMTRAGRU Memphis	23	72	24	25
	B6662800	CBU 404	33	33	39	35
	B6863200	PERSUPPACT Memphis	0	0	250	262
Total			1233	1508	1515	1445
Meridian, MS	B3273900	NAVTECHTRACEN Meridian	51	62	31	38
	B3328000	NAS Meridian MS/BCT	15	18	3	3
	B6304300	NAS Meridian Miss	542	548	490	465
Total			608	628	524	506
Monterey, CA	B6227100	NAVPGSCOL Monterey Cal	314	307	308	311
Newport, RI	B0012400	NAVWARCOL Newport RI	0	0	0	86
	B4326900	SWOSCOLCOM Newport RI/BOS	0	0	14	6
	B6266100	NETC Newport	922	933	902	841
	B6319000	SWOSCOLCOM Newport	0	0	0	9
	B6861100	PERSUPPACT Newport RI	0	0	0	133
Total			922	933	916	1075
New London, CT	B0075000	NAVSUBSCOL New London Conn	53	93	57	49
Norfolk, VA	B6179700	FLETRACEN Norfolk VA	12	49	24	22
	B6332500	NAVTRADEVCEN Norfolk VA	46	54	53	53
	B6340100	FLEASWTRACENLANT	26	48	27	24
	B6435600	NAVADMINCOM AFSC Norfolk VA	81	74	80	72
Total			165	225	184	171
Orlando, FL	B0617A00	NAVNUPWRSCOL Orlando FL	0	0	0	43
	B3327300	NTC Orlando/BCT	23	26	20	9
	B4311400	NAVSERVSCOLCOM Orlando/BOS	0	0	11	2
	B6133900	NAVTRAEQUIPCEN Orlando	111	86	84	88
	B6592800	NTC Orlando	529	443	76	84
	B6593100	NAVSERVSCOLCOM Orlando	0	0	0	13
	B6849700	NAVADMINCOM NTC Orlando	361	363	813	853
	B6860600	PERSUPPACT Orlando	0	29	173	232
Total			1024	947	1177	1324
Pearl Harbor, HI	B6315400	FLESUBTRAFAC Pearl Harbor	30	295	29	33

Note. Data includes total active duty officer and enlisted and U.S. civilians. Obtained from NCIS data base.

Table 2 (Continued)

Location	UIC	UIC Title	FY78	FY79	FY80	FY81
Pensacola, FL	B0020300	NAS Pensacola FLA FLTRA	1534	1341	1512	1261
	B3328100	NAS Pensacola/BCT	63	60	59	23
	B3328300	NAS Whiting FLD Milton FL/BCT	16	14	14	4
	B4212400	NAVEDTRAPRODEVCEN PNCLA/BCT	14	13	9	0
	B6050800	NAS Whiting FLD Milton FL	559	559	570	567
	B6308200	NTTC PNCLA CRYPTO	0	0	0	229
	B6661000	CBU 402	40	50	50	45
	B6832200	NAVEDTRAPRODEVCEN PNCLA	91	300	274	69
	B6854000	MIISA NAS Pensacola	161	179	103	167
	B6856600	CNET ACCTSUPPCEN NAS PNCLA	0	197	195	216
	B6860900	PERSUPPACT Pensacola	0	0	0	360
Total			2478	2713	2786	2941
Philadelphia, PA	B6315900	NAVDAMCONTRACEN Phila PA	13	16	13	12
San Diego, CA	B0024700	NTC San Diego CA	180	149	34	41
	B0094800	FLTASWSCOL San Diego CA	52	65	63	58
	B0414A00	NAVADMINCOM San Diego CA	457	399	487	448
	B0581A00	NAVSERVSCOLCOM San Diego	0	0	0	62
	B3195400	NAVSUBTRACENPACREP San Diego		0	0	0
	B4213100	NTC San Diego/BCT	0	1	0	0
	B4213300	SWOSCOLCOM DET Coron/Base OPS		0	3	3
	B4330400	SUBTRAFAC San Diego BOS	0	0	11	4
	B6166500	FASWTRACEN San Diego CA	81	98	89	89
	B6169000	FLETRACEN San Diego	23	46	34	37
	B6301500	NAVEDTRASUPPCENPAC San Diego		138	155	180
	B6301800	NAVPHIBSCOL Coronado CA	12	165	35	12
	B6855200	PERSUPPACT NTC San Diego	59	221	235	266
Total			1002	1302	1171	1189
San Francisco, CA	B6262900	NAVTECHTRACEN TI SFran	22	23	20	17
	B6329000	COMBATSYSTECHSCHOLSCOM Mare Is	36	109	35	24
Total			58	132	55	41
Schenectady, NY	B4313500	NPTU Ballston SPA BOS	0	0	8	0
	B6298600	NAVNUPWRTRAU Schenectady NY	0	0	0	8
	B6831700	NAVADMINU Scotia NY	22	20	17	20
Total			22	20	25	28

Note. Data includes total active duty officer and enlisted and U.S. civilians. Obtained from NCIS data base.

Table 3

Host-Tenant List by Location

Location	UIC	Activity Name
Annapolis	00161	USNA Annapolis MD
	00161	USNA Annapolis MD
	64377	Navy Band USNA Annapolis
	62226	NAVSTA Annapolis MD
	62226	NAVSTA Annapolis MD
Athens, GA	62741	NAVSCSCOL Athens
Chase Field, TX	60374	NAS Chase Field
	0403A	TRARON TWENTYFOUR
	0404A	TRARON TWENTYFIVE
	0405A	TRARON TWENTYSIX
	09350	TRAWING THREE
	42097	NAS Chase Field/UPT
	66056	NAMTRADET
Charleston, SC	62603	FLEMINEWARTRACEN
	62603	FLEMINEWARTRACEN
	63322	FLEBALMISUBTRACEN
	63322	FLEBALMISUBTRACEN
Corpus Christi, TX	00216	NAS Corpus Christi
	0406A	TRARON TWENTYSIX
	0407A	TRARON TWENTYEIGHT
	0410A	TRARON THIRTYONE
	52812	TRAWING FOUR
	42094	NAS Corpus Christi/UPT
	63110	CNATRA
	68113	CAA CEN NAS Corpus Christi
	68432	TRAWING FOUR Maint Tra Unit
Dam Neck, VA	00281	FLTCOMBATRACENLANT
	00281	FLTCOMBATRACENLANT
	42087	FLTCOMBATRACENLANT GST
	64619	NAVGMSCOL Dam Neck
Great Lakes, IL	00210	NTC Great Lakes
	0580A	Service School Command Great Lakes
	0763A	Recruit TRNG Command Great lakes
	62915	COMNAVCRUITAREA 5
	66892	EDTRASUPPCEN Great Lakes
	68108	CAA CEN ADCOM Great Lakes
Gulfport, MS	65971	NAVCONSTRACEN Gulfport
	65971	NAVCONSTRACEN Gulfport
Idaho Falls, ID	65198	NAVADMINU Idaho Falls
	62985	Nuclear Power Training Unit Idaho Falls
Indian Head, MD	62640	NAVSCOLEOD Indian Head
	62640	NAVSCOLEOD Indian Head
	42136	NAVSCOLEOD/GST
Kingsville, TX	60241	NAS Kingsville
	0400A	TRARON TWENTYONE
	0401A	TRARON TWENTYTWO
	0402A	TRARON TWENTYTHREE
	09239	TRAWING TWO
	66057	NAMTRADET
	09278	JTTU Kingsville
	42095	NAS Kingsville/UPT

Table 3 (Continued)

Location	UIC	Activity Name
Lakehurst, NJ	63094	NATTC Lakehurst
	63094	NATTC Lakehurst
	42114	NATTC Lakehurst/GST
Little Creek, VA	0618A	School of Music Little Creek
	0618A	School of Music Little Creek
	42112	School of Music Little Creek/GST
	63021	NAVPHIBSCOL Little Creek
	63201	NAVPHIBSCOL Little Creek
	42152	NAVPHIBSCOL Little Creek/GST
Mayport, FL	10151	FLETRACEN Mayport
	10151	FLETRACEN Mayport
	42145	FLETRACEN Mayport/GST
	66069	NAMTRADET
	62741	NAVSCSCOL Athens
Memphis, TN	00639	NAS Memphis
	63093	NATTC Memphis
	42146	NATTC Memphis/GST
	42454	NAMTRADET
	68260	HRMS Memphis
	42148	NAMTRAGRU Memphis/GST
	63111	CNTECHTRA Memphis
	68123	CAA CEN NAS Memphis
Meridian, MS	63043	NAS Meridian
	0398A	TRARON SEVEN
	0399A	TRARON NINE
	09177	TRARON NINETEEN
	09251	TRAWING ONE
	32739	NTTC Meridian
	42141	NTTC Meridian/GST
	42105	NAS Meridian/UPT
	66055	NAMTRADET
Monterey, CA	62271	Naval Post-Graduate School
	42091	NAVPGSCOL Monterey/PROFTRA
	42525	IRA NAVPGSCOL Monterey
	62271	Naval Post Graduate School
	65522	DRMEC
Newport, RI	62661	NETC Newport
	47115	NETC Newport/OCS Training
	42130	NETC Newport/GST
	43291	NACU Newport (NETC)
	43728	Senior Enlisted Academy
	62661	NETC Newport
	62750	NAVJUSTSCOL
	63190	SWOSCOLCOM Newport
	43269	SWOSCOLCOM Newport/GST
	66128	NAPS
	00124	NAVWARCOL Newport
	00124	NAVWARCOL Newport
	42134	NAVWARCOL Newport/PMT
New London, CN	00750	NAVSUBSCOL Groton
	00750	NAVSUBSCOL Groton
	42135	NAVSUBSCOL Groton/GST

Table 3 (Continued)

Location	UIC	Activity Name
Norfolk, VA	61797	FLETRACEN Norfolk
	61797	FLETRACEN Norfolk
	42090	FLETRACEN Norfolk/GST
	0387A	FITC
	63401	FLEASWTRACEN
	63401	FLEASWTRACEN
	42139	FLEASWTRACEN
	64356	Armed Forces Staff College
	61720	Armed Forces Staff College
	64356	Armed Forces Staff College
Orlando, FL	65928	NTC Orlando
	0617A	NAVNUPWRSCOL Orlando
	42086	NTC Orlando/GST
	43422	NAVTRAEQUIPCEN/ISD
	43424	NAVTRAEQUIPCEN/SOM
	61339	NAVTRAEQUIPCEN Orlando
	65930	Recruit Training Command
	65931	Service School Command
Pearl Harbor, HI	63154	SUBTRAFAC Pearl
	63154	SUBTRAFAC Pearl
	42142	SUBTRAFAC Pearl/GST
Pensacola, FL	00204	NAS Pensacola
	00062	CNET Pensacola
	0395A	TRARON FOUR
	0432A	NAVAMUSEUM PNCLA
	0614A	TRATRON TEN
	30929	Flight Demonstration Team CNATRA
	35697	DEFACTEDSUP PNCLA
	42093	NAS PENSACOLA/UNT
	42098	Tuition Aid CNET Support PENCLA
	42099	NAVAVSCOL COMM PNCLA/UNT
	42101	NAVEDTRAPRODEV CEN PENCLA
	42116	NTTC CORRY
	42123	NAS Pensacola A/C OPS DET/UPT
	42155	CNET Command Printing
	43426-43430	NAVEDTRAPRODEVCEN PENCLA
	52814	TRAWING SIX
	52902	TRARON EIGHTYSIX
	60234	NAS Saufley Fld Pensacola
	62229	NAVAVSCOLCOM
	63096	NTTC PHOTO TRNG CORRY
	66896	CNETS PNCLA
	68055	NTTC CORRY ELECTRONIC WAR
	68119	CAA CEN NAS PNCLA
	60508	NAS Whiting Field
	0393A	TRARON TWO
	0394A	TRARON SIX
	0397A	TRARON SIX
	0411A	HELTRATRON EIGHT
	42096	NAS Whiting Field/UPT
	52813	TRAWING FIVE
	52838	HELTRATRON EIGHTEEN
	66534	NAMTRADET
Philadelphia, PA	63159	NAVDAMCONTRACEN Phila
	63159	NAVDAMCONTRACEN Phila
	42108	NAVDAMCONTRACEN Phila/GST

Table 3 (Continued)

Location	UIC	Activity Name
San Diego, CA	61690	FLETRACEN SD
	61690	FLETRACEN SD
	42149	FLETRACEN SD/GST
	C0208	FLETRACEN/GST
	42133	SWOSCOLCOM
	39037	SWOSCOLCOM
	63018	NAVPHIBSCOL CORONADO
	63018	NAVPHIBSCOL CORONADO
	42147	NAVPHIBSCOL CORONADO/GST
	31954	SUBTRAFAC San Diego
	31954	SUBTRAFAC San Diego
	00247	NTC San Diego
	0581A	Service School Command San Diego
	0753A	Recruit Training Command San Diego
	42084	NTC/GST
	42132	SSC Broad Support OFCR SEL TRA
	42820	CAA CEN ADCOM NTC
	00948	FLEASWTRACENPAC
	00948	FLEASWTRACENPAC
	42851	FLEASWTRACENPAC/GST
	C0223	FLEASWTRACENPAC/GST SURF
	0388A	FITCPAC
	61665	FLTCOMBATRACENPAC
	61665	FLTCOMBATRACENPAC
	42852	FLTCOMBATRACENPAC/GST
	63015	NAVEDTRASUPCENPAC
	43404-43409	NAVEDTRASUPPCENPAC
San Francisco, CA	62639	NTTC Treasure Island
	62639	NTTC Treasure Island
	42117	NTTC Treasure Island/GST
	63236	NAVSCOLPHYSDISTMGT
	42150	NAVSCOLPHYSDISTMGT/GST
	63290	COMBAT SYSTECHSCOLCOM MI
	63290	COMBAT SYSTECHSCOLCOM MI
	42118	COMBAT SYSTECHSCOLCOM/GST
	41603	EDO SCHOOL MARE ISLAND
Schnectady, NY	68317	NAVADMINU SCOTIA
	62986	Nuclear Power Training Unit

Table 4

Student Workload and Tenant Population End Strengths
By Location

Location	FY78	FY79	FY80	FY81
Student Workload[a]				
Annapolis, MD	4183	4245	4278	4425
Athens, GA	236	271	326	344
Chase Field, TX	163	154	156	177
Charleston, SC	643	647	519	547
Corpus Christi, TX	90	223	239	258
Dam Neck, VA	1472	1691	1530	1613
Great Lakes, IL	13629	10786	14612	15013
Gulfport, MS	70	304	371	391
Idaho Falls, ID	770	747	800	805
Indian Head, MD	323	253	230	342
Kingsville, TX	182	174	156	177
Lakehurst, NJ	348	--[b]	407	429
Little Greek, VA	243	733	633	667
Mayport, FL	124	116	226	238
Memphis, TN	6641	6327	7539	7948
Meridian, MS	957	835	902	957
Monterey, CA	1028	1166	1324	1374
Newport, RI	1469	1577	1590	2097
New London, CN	1741	2090	2134	2250
Norfolk, VA	1734	1359	2005	2157
Orlando, FL	8235	9024	9604	9983
Pearl Harbor, HI	500	479	431	454
Pensacola, FL	3228	2436	3672	4083
Philadelphia, PA	--[b]	267	369	389
San Diego, CA	12124	10481	12485	12868
San Francisco, CA	1631	958	1058	1115
Schnectady, NY	721	1023	584	593
Tenant Population[c]				
Annapolis, MD	1619	1605	1613	1605
Athens, GA	56	57	54	66
Chase Field, TX	1295	1293	1276	1329
Charleston, SC	456	444	443	472
Corpus Christi, TX	1452	1296	1244	1190
Dam Neck, VA	919	1148	1248	1259
Great Lakes, IL	2230	2080	1971	2032
Gulfport, MS	143	145	129	132
Idaho Falls, ID	625	578	657	595
Indian Head, MD	67	8	85	92
Kingsville, TX	1345	1388	1325	1363
Lakehurst, NJ	155	151	145	159
Little Creek, VA	160	74	129	142
Mayport, FL	98	92	112	92
Memphis, TN	1668	1296	1425	1344
Meridian, MS	996	1067	1068	1036
Monterey, CA	496	474	447	480
Newport, RI	783	847	890	930
New London, CN	698	687	730	797
Norfolk, VA	655	136	681	707
Orlando, FL	1002	1059	1288	1118
Pearl Harbor, HI	317	33	311	279
Pensacola, FL	5203	4555	4724	4600
Philadelphia, PA	65	63	71	73
San Diego, CA	2793	2660	3271	3149
San Francisco, CA	565	496	551	590
Schectady, NY	638	700	719	763

[a]From FY78-81 MMTR.

[b]Missing data.

[c]Data includes those for active duty enlisted and officer and U.S. civilians. From 1981 NCIS except for NAMTRADETs, which were obtained from CNET.

Table 5

Facility Size and Age Data by Location

Location[a]	AGE[b]	WVALAGE[c]	AREA[d]
Annapolis, MD	44	65	5534
Athens, GA	27	40	392
Chase Field, TX	18	24	1602
Charleston, SC	20	17	313
Corpus Christi, TX	21	34	5790
Dam Neck, VA	24	25	1503
Great Lakes, Il	31	30	7874
Gulfport, MS*	--	--	--
Idaho Falls, ID	--	--	24
Indian Head, MD*	--	--	--
Kingsville, TX	23	22	1544
Lakehurst, NJ*	--	--	--
Little Creek, VA*	--	--	--
Mayport, FL*	--	--	--
Memphis, TN	24	25	6115
Meridian, MS	16	15	2134
Monterey, CA	25	34	2546
Newport, RI	24	31	6725
New London, CN*	--	--	--
Norfolk, VA	28	24	641
Orlando, FL	20	17	6112
Pearl Harbor, HI*	--	--	--
Pensacola, FL	27	127	10064
Philadelphia, PA	32	35	96
San Diego, CA	32	28	5189
San Francisco, CA*	--	--	--
Schnectady, NY	--	--	3

Note. From Navy facilities assests data base, FY 1980.

[a]Asterisks indicate that locations have no associated building area (i.e., RPMA services are provided by nontraining hosts).

[b]Average age of all buildings to nearest year.

[c]Average age weighted by plant value rounded to nearest year.

[d]Total square footage of building area (unit = 100,000 sq. ft.).

Table 6

Types of Training by Location

Location	Enlisted Recruit	Officer Professional Development	Enlisted Specialized	Officer Flight	Officer Acquisition
Annapolis, MD	--	--	--	--	X
Athens, GA	--	--	X	--	--
Chase Field, TX	--	--	--	X	--
Charleston, SC	--	--	X	--	--
Corpus Christi, TX	--	--	--	X	--
Dam Neck, VA	--	--	X	--	--
Great Lakes, IL	X	--	X	--	--
Gulfport, MS	--	--	X	--	--
Idaho Falls, ID	--	--	X	--	--
Indian Head, MD	--	--	X	--	--
Kingsville, TX	--	--	--	X	--
Lakehurst, NJ	--	--	X	--	--
Little Creek, VA	--	--	X	--	--
Mayport, FL	--	--	X	--	--
Memphis, TN[a]	--	--	X	--	--
Meridian, MS	--	--	X	X	--
Monterey, CA	--	X	--	--	--
Newport, RI	--	X	X	--	X
New London, CN	--	--	X	--	--
Norfolk, VA	--	X	X	--	--
Orlando, FL	X	--	X	--	--
Pearl Harbor, HI	--	--	X	--	--
Pensacola, FL	--	--	X	X	X
Philadelphia, PA	--	--	X	--	--
San Diego, CA	X	--	X	--	--
San Francisco, CA	--	-	X	--	--
Schenectedy, NY	--	--	X	--	--

[a]Since NAS Memphis is used almost exclusively for reserve support, it is not associated with flight training.

Table 7

Candidate Independent Variables for BOS Training Requirements

Workload Factor	Variable Name	Variable Description
Facility size and age	AREA	Total square footage of building area maintained by BOS training hosts
	PCTQIN	Percentage of AREA considered "inadequate"
	PCTQSBIN	Percentage of AREA considered "substandard" or "inadequate"
	PCTHOUSE	Percentage of AREA use for housing
	AGE	Mean age of buildings
	WAREAGE	Mean age weighted by AREA
	WVALAGE	Mean age weighted by plant value
Student load	WORKLOAD	Student workload data (MMTR)
	LOAD	Student workload data (NITRAS and CNET cost accounting system)
	NOCRSES	Number of courses taught at activity
	CRSEDAYS	Total course days (course length x convening frequency)
	CRSECAP	Maximum student capacity at activity
Tenant population supported	TENANT	Total tenant population, excluding students
	TENCIV	Civilian component of TENANT
	TENMIL	Military component of TENANT

RESULTS

Preliminary Analysis

This section presents the preliminary findings that guided the logic leading to the eventual two equation model. Table 8 shows the correlations of BOS-training manpower (BOSMP) with AREA, WORKLOAD, and TENANT. These variables were the "best" at this stage in the analysis and represent each of the three potential factors: facility size and age, student workload, and tenant population supported.

Table 8

Correlations of BOSMP With AREA, WORKLOAD, and TENANT Variables

Variable	BOSMP	AREA	WORKLOAD	TENANT
BOSMP	1.00	.94	.55	.89
AREA		1.00	.65	.80
WORKLOAD			1.00	.54
TENANT				1.00

Notes.

1. Based on only 106 observations since student workload for Philadelphia in FY78 and Lakehurst in FY79 were not available.
2. Variables defined in Table 7.

It is evident that AREA is the dominant variable in predicting BOSMP. Table 9 lists the usual R^2 statistic, showing the percentage of variation in BOSMP "explained," for each combination of these variables. Not only does AREA explain most of the variance, but WORKLOAD enters every multiple regression equation with a negative coefficient in the presence of AREA.

Table 9

R-Square Statistics for AREA, WORKLOAD, and TENANT Variables

Variable	R^2
WORKLOAD	.303
TENANT	.792
WORKLOAD, TENANT	.799
AREA	.887
AREA, WORKLOAD	.893
AREA, TENANT	.940
AREA, WORKLOAD, TENANT	.949

There are two fundamentally different types of services afforded by BOS--maintenance of the physical plant and other base services that, within the BOS-training program elements, are oriented towards personnel and administrative support. Conceptually, the former should be related to facility size measures; and the latter, to student and other tenant populations served by the host activities. Fortunately, the activity/subactivity group breakdown afforded by the FY81 NCIS (see Table 10) allows for BOSMP to be divided into these respective components. BOSMP (for FY81) was then divided as follows: BOSMP = BOSRPMA + BOSDIFF, where BOSRPMA was defined to be the real property maintenance (RPMA) manpower, reported against the F4 activity group; and BOSDIFF, other base services manpower, reported against the F3 activity group. Table 11 shows the values for BOSRPMA and BOSDIFF by location. Table 12, which provides the correlation between the BOSMP components and the three variables representing the workload factors, shows that WORKLOAD and TENANT showed stronger correlations with BOSDIFF than with BOSRPMA, as expected. Thus, it was concluded that BOSRPMA and BOSDIFF should be modelled separately.

Table 10

BOS Training End Strength by Activity/Subactivity Group

Activity/Subactivity Group	Title	FY81 End Strength
F3BE	BOS-OTHER-ACFT FLIGHT OPERATIONS	76
F3BQ	BOS-OTHER-ACFT OPS MAINTENANCE	113
F3FF	BOS-OTHER-ADMINISTRATION	3903
F3FG	BOS-OTHER-RETAIL SUPPLY OPERATIONS	1804
F3FH	BOS-OTHER-MAINT OF INSTALL EQUIPMENT	45
F3FJ	BOS-OTHER-BACH HSG OPERATIONS & FURNISHI	592
F3FK	BOS-OTHER-OTHER PERSONNEL SUPPORT	1608
F3FL	BOS-OTHER-MORALE WELFARE & RECREATION	522
F3FM	BOS-OTHER-HOSP/CLINICS/DISP (NON-MED)	26
F3FN	BOS-OTHER-BASE COMMUNICATIONS	189
F3FQ	BOS-OTHER-ADP SERVICES	230
F3FR	BOS-OTHER-OTHER BASE SERVICES	1484
F3FS	BOS-OTHER-OTHER AIRCRAFT SUPPORT	52
F3LZ	BOS-OTHER-HUMAN GOALS	19
F4FA	BOS/RPMA-MAINT/REPAIR OF REAL PROP	1388
F4FB	BOS-RPMA-MINOR CONSTRUCTION	175
F4FC	BOS/RPMA-OPERATION OF UTILITIES	238
F4FD	BOS/RPMA-OTHER ENG SUPPORT	1361
MXL2	OFF-DU&VOL ED PROG-NAVY CAMPUS-ACHIEVMNT	2
M6GR	OTHER TRAINING SUPPORT-INST SYTEMS DEV	21
M6MN	OTHER TRAINING SUPP-SIMULATOR ACQUISIT	51
M6MP	OTHER TRAINING SUPP-SIMULATOR OP & MAINT	4
M6MS	OTHER TRAINING SUPP-ADVANCEMENT IN RATE	9
M68T	OTHER TRAINING SUPP-TRAINING SUPPORT	52
PY	MILITARY/CIVILIAN MANPOWER	0
PYPY	MILITARY/CIVILIAN MANPOWER-MIL/CIV MNPWR	6
V100	SAG UNDISTRIBUTED/NARM-FLAIL	84
1013	MILPERS ASSIGNED OTH DOD AG-AIR FORCE	1
8585	LAUNDRY SERVICE NAVCADPERS-LAUNDRY SERV	78

Table 11

BOSMP Component End Strengths by Location for FY81

Location	BOSRPMA OFF	BOSRPMA ENL	BOSRPMA CIV	BOSDIFF OFF	BOSDIFF ENL	BOSDIFF CIV	TNGPWCMP[a]
Annapolis, MD	0	0	460	24	48	338	0
Athens, GA	1	0	23	8	25	9	0
Chase Field, TX	3	28	169	14	138	141	0
Charleston, SC	0	0	0	5	19	16	0
Corpus Christi, TX	4	53	337	41	421	391	0
Dam Neck, VA	3	0	115	14	151	72	0
Great Lakes, IL	3	60	1	62	770	429	289
Gulfport, MS	0	1	0	1	10	0	0
Idaho Falls, ID	0	0	4	6	33	3	0
Indian Head, MD	0	0	0	1	5	3	0
Kingsville, TX	2	23	143	18	178	113	0
Lakehurst, NJ	0	0	0	5	17	5	0
Little Creek, VA	0	0	0	1	9	7	0
Mayport, FL	0	0	0	0	3	1	0
Memphis, TN	5	35	320	46	666	373	0
Meridian, MS	2	17	123	18	221	125	0
Monterey, CA	3	1	120	21	66	100	0
Newport, RI	5	2	317	32	309	356	0
New London, CN	1	3	0	6	20	19	0
Norfolk, VA	2	12	6	15	70	66	44
Orlando, FL	5	0	254	62	669	334	0
Pearl Harbor, HI	0	5	0	6	16	6	25
Pensacola, FL	7	71	333	84	1080	1366	312
Philadelphia, PA	0	0	5	1	6	0	0
San Diego, CA	3	29	40	82	747	288	205
San Francisco, CA	2	0	4	3	25	7	13
Schnectady, NY	0	0	4	2	12	10	0

[a]PWC manpower estimated to be in support of the training activities.

Table 12

Correlations of BOSRPMA and BOSDIFF With Variables Representing Workload Factors (N = 27)

Variable[a]	BOSMP	BOSRPMA	BOSDIFF
AREA	.96	.81	.92
WORKLOAD	.59	.25	.64
TENANT	.88	.57	.90

[a]Variables are defined in Table 7.

Since the activity group breakdown was available only for FY81, it was necessary to estimate the split for the earlier years. Conceptually, the RPMA component represents the fixed (at least in the near term) manpower requirements resulting from facility size. Therefore, it was decided that BOSRPMA would be defined as constant over all years. Year-to-year variations in BOSMP were attributable to the BOSDIFF variation. This assumption is also consistent with the fact that the size variables are essentially constant over time for each location.

Development of the BOSRPMA Model

Since PWCs support RPMA functions, BOSRPMA was adjusted to reflect this outside source of support to BOS hosts:

$$\text{TOTRPMA} = \text{BOSRPMA} + \text{TNGPWCMP},$$

where TOTRPMA is the total RPMA manpower and TNGPWCMP is the PWC manpower estimated to be in support of the training activities. This estimate was based upon the distribution of revenues from PWC customers as collected in a survey of PWCs discussed earlier (p. 4). Table 13 presents the correlation of BOSRPMA and TOTRPMA with the three facility size and age variables that are considered to represent the best subset of indicators for that workload factor. As shown, TOTRPMA correlates more highly with all of these variables than does BOSRPMA. Thus, the RPMA portion of the model is best estimated using the TOTRPMA variable. Considerations of how to adjust for the PWC contribution during model implementation are discussed on p. 35. Table 14 shows some summary statistics for the variables considered for the RPMA model.

Table 13

Correlations of BOSRPMA and TOTRPMA With Facility Size and Age Variables

Variable	BOSRPMA	TOTRPMA	AREA	AGE	WVALAGE
BOSRPMA	1.00	.89	.81	.55	.66
TOTRPMA		1.00	.96	.61	.81
AREA			1.00	.60	.71
AGE				1.00	.69
WVALAGE					1.00

Notes.

1. N = 27 except for correlations with AGE, WVALAGE, where N = 25.
2. Facility size and age variables are defined in Table 7.

Table 14

Statistics For RPMA Variables

Variable	Number of Observations	Mean	Std Dev	Min	Max
BOSRPMA	27	119	154	0	460
TOTRPMA	27	152	189	0	723
AREA	27	2386	3048	0	10064
AGE	25	18	14	0	44
WVALAGE	25	24	27	0	127

AREA explains 92 percent of the variance in TOTRPMA; and AREA and WVALAGE together, 95 percent. The resulting regression equation is shown below (t values in parentheses are all significant at the .001 level):

$$\text{TOTRPMA} = \underset{(11.16)}{(.047 \cdot \text{AREA})} + \underset{(4.03)}{(1.94 \cdot \text{WVALAGE})} - 3.12.$$

The coefficient of WVALAGE implies that an increase in overall age (weighted by plant value) of 1 year adds approximately two persons to the RPMA requirement. However, the high correlation between AREA and WVALAGE (.71--see Table 13) weakens this interpretation. Moreover, the usefulness of this equation over a 15-20 year period is questionable since it would be difficult to forecast the values of WVALAGE.

Tests were performed to see if certain type of activities differed significantly from the AREA-driven equation. Dummy variables for each location were included to further test for outlier observations. When dummy variables for the locations were considered in the presence of AREA, those for Great Lakes and Orlando were the first to enter. This suggested the use of a dummy variable for recruit training (RTC FLAG), which is set to "1" for the recruit training complexes (Orlando, San Diego, and Great Lakes), and "0" elsewhere. Table 15 presents the recommended RPMA equation.

Table 15

Least Squares Regression of TOTRPMA With AREA, and RTCFLAG
(Overall R^2 = .957)

Variable	Coefficient	Standard Error	t	Significance Prob t
Intercept	9.696	10.001	.97	.3424
AREA	.066	.003	22.25	.0001
RTCFLAG	-135.570	28.265	-4.80	.0001

A nice feature of this equation is that the intercept is not significantly different from zero; thus, no AREA to maintain implies no BOSRPMA manpower required. Furthermore, the locations that had no associated building area all have a nontraining host. The inference, which was confirmed by inspecting the Navy facilities assets data base (NFADB), is that the support provided by nontraining hosts to training activities is solely of a RPMA nature.

The plot of AREA versus total real property maintenance manpower (TOTRPMA) is shown in Figure 1; the plot of residuals for this equation is shown in Figure 2. A common procedure in checking for heteroscedasticity (unequal variance among the error terms) is to plot the residuals of the model against the dependent or independent variables. Plots of the residuals with AREA and with total TOTRPMA are shown in Figures 3 and 4 respectively. Figure 3 indicates a slight tendency for the errors to indeed increase with facility size, as measured by AREA. To correct for this, it is appropriate to use weighted least squares (see, for example, Judge, Griffiths, & Lee, 1980), with a weighting factor equal to the reciprocal of AREA. When this was done, the overall R^2 value actually decreased and the coefficient of AREA showed no signficant change (from .066 to .068). Furthermore, the use of the equation at the aggregate (across all locations) level makes the heteroscedasticity question less relevant.

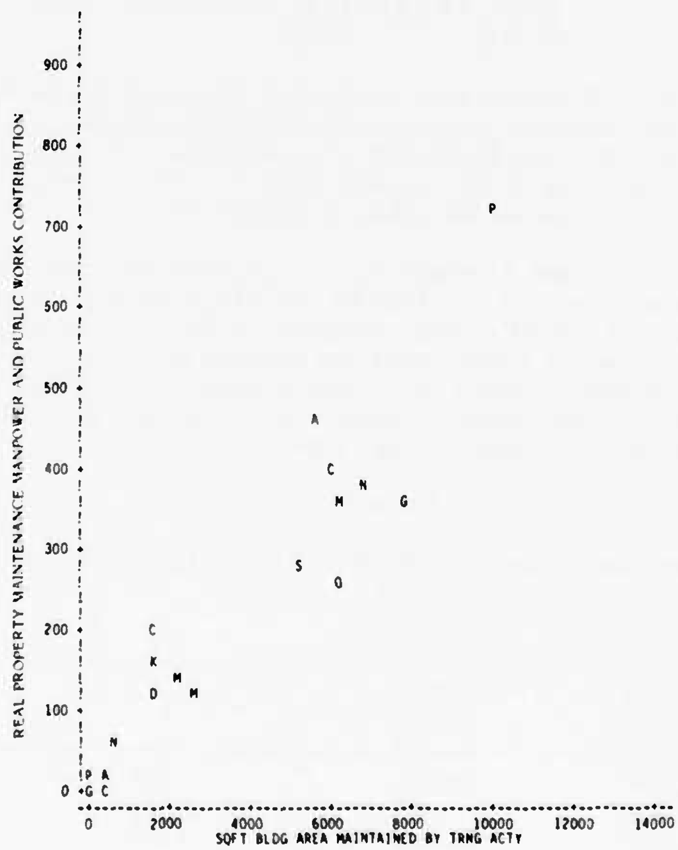

Figure 1. Area versus TOTRPMA.

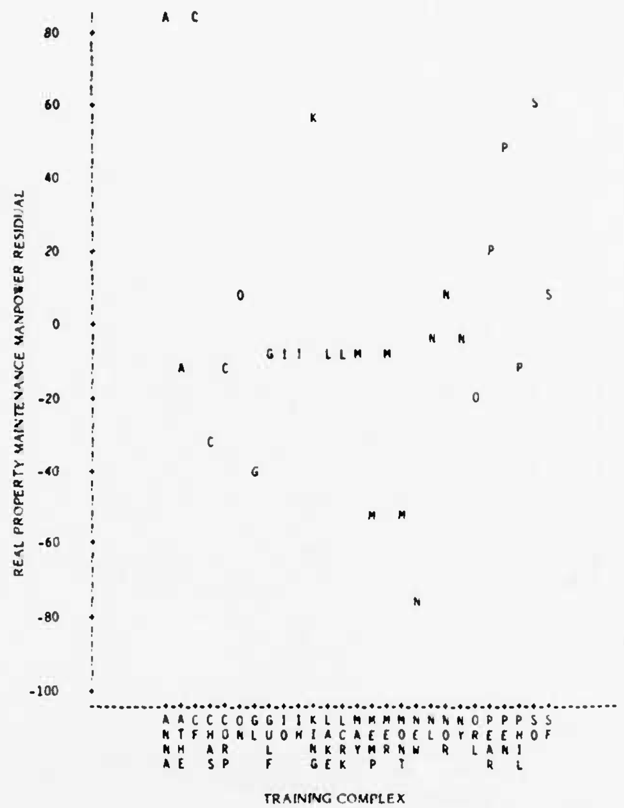

Figure 2. Residual plot for TOTRPMA equation.

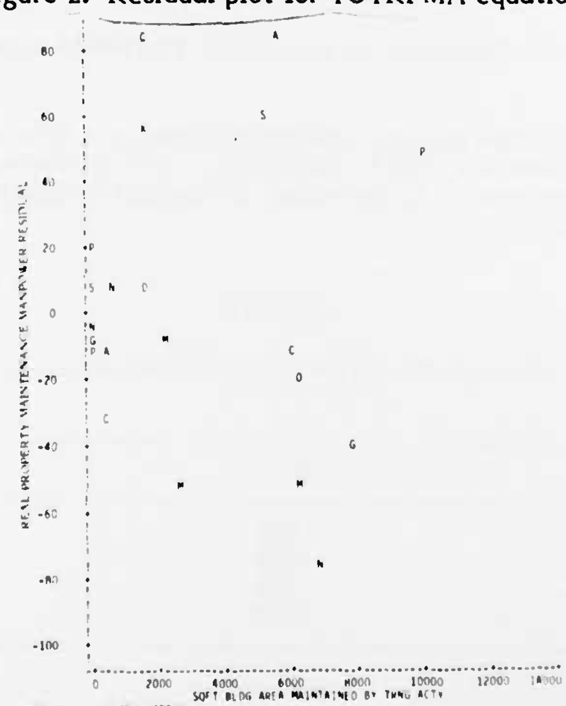

Figure 3. Residuals vs. area for TOTRPMA equaton.

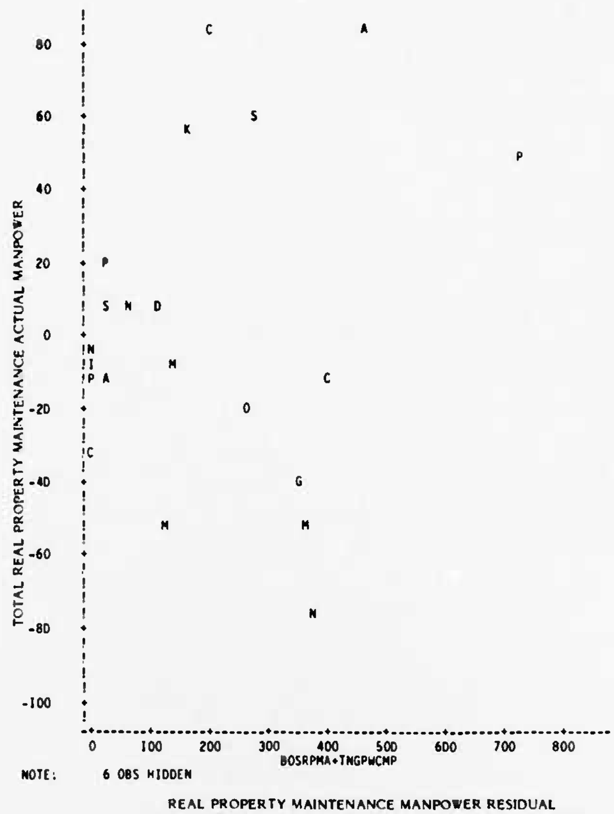

Figure 4. Residuals vs. actuals for TOTRPMA equation.

The four most significant outliers were dropped one at a time to check for sensitivity in both the overall fit and the AREA coefficient. The differences obtained, which are shown in Table 16, did not seem large enough to warrant dropping one or more of these locations from the model.

Table 16

Influence Of Outliers In TOTRPMA Equation

Model	R^2	Coefficient of AREA
Without Annapolis	.957	.066
Without Newport	.962	.064
Without Memphis	.959	.067
Without Chase Field	.965	.066

Development of the BOSDIFF Model

BOSDIFF, by definition, is the portion of BOSMP remaining after subtracting the FY81 manpower reported against the F4 (RPMA) activity group. Strictly speaking, this remainder is not all directly related toward personnel type support; for example, the ADP (F3FQ) group (see Table 10) is not being intuitively driven by either student workload or tenant population. Experimentation with defining a variable as being made up of personnel-related functions only was performed but this distinction proved to be so minor that it was subsequently dropped. The Air Station at Memphis is unique in that approximately 200 persons, representing 17 percent of the F3 activity group total, were reported against the BE (Aircraft Flight Operations) and BQ (Aircraft Operations Maintenance) subactivity groups. Dropping this manpower from BOSDIFF did not appreciably change the correlations.

Table 17 provides correlations between representative workload measures; and Table 18, summary statistics. The workload variable (LOAD), coming from NITRAS and CNET's cost accounting system, is statistically identical with the student workload variable (WORKLOAD) contained in the MMTR. It was decided to use the MMTR data because of its consistency over all years and types of training.

Table 17

Correlations Of BOSDIFF With Representative Workload Variables

Variable[a]	BOSDIFF	WORKLOAD	LOAD	TENANT
BOSDIFF	1.00	.60	.61	.91
WORKLOAD		1.00	.98	.54
LOAD			1.00	.57
TENANT				1.00

[a]Variables are defined in Table 7.

Table 18

Summary Statistics For BOSDIFF And Representative Workload Variables

Variable[a]	N	Mean	Std Dev	Min	Max
BOSDIFF	108	383	527	0	2530
WORKLOAD	106	2460	3679	70	15013
LOAD	81	2240	3462	98	15651
TENANT	108	962	1022	8	5203

[a]Variables are defined in Table 7.

The early analysis indicated that the civilian component of the tenant variable (TENCIV) was superior to either the military component (TENMIL) or TENANT (total of TENMIL and TENCIV) because it had a reduced intercorrelation with WORKLOAD. However, this was misleading because TENCIV is such a small percentage of the total tenant population. Therefore, TENANT was chosen as the more appropriate variable.

WORKLOAD alone accounts for only 36 percent of the variation in BOSDIFF, a disappointing result. Other measures of student presence (e.g., number of courses, total course days, or course days weighted by the maximum capacity of each class) were averaged over the courses at a complex. However, since none of these entered a stepwise regression equation with TENANT included, they were dropped from further consideration.

If dummy variables for each location were introduced along with the WORKLOAD and TENANT variables, the results shown in Table 19 were obtained. The location dummy variables entered the equation in the order that maximizes the overall R^2. Significantly, all but Newport are associated with air stations, suggesting that they should perhaps be modelled separately. It was decided to include a dummy variable NASFLAG, with a value of "1" at complexes associated with air stations and "0" elsewhere. The resulting regression statistics were vastly improved.

Table 19

Regression Statistics for BOSDIFF Equation with Dummy Variables for Each Location Included

Step	Variables	Location Dummy	Overall R^2
0	TENANT, WORKLOAD		.843
3		Pensacola	.884
4		Corpus Christi	.918
5		Memphis	.940
6		Newport	.957
7		Meridian	.965
8		Chase Field	.969
9		Kingsville	.977

Figures 5 and 6 show BOSDIFF versus WORKLOAD and TENANT respectively. When air stations were excluded, WORKLOAD alone explained 88 percent of the variance in BOSDIFF. Somewhat surprisingly, TENANT added no additional explanatory power. For the admittedly small sample (six locations) of air stations, TENANT explained 83 percent of BOSDIFF with WORKLOAD insignificant in the presence of TENANT. Consequently, the analysis finally produced the equation shown in Table 20, which involves WORKLOAD for all locations and TENANT only at the air station locations. Once again, the intercept term is essentially zero. Since the intercorrelation between WORKLOAD and NASTEN (.003) was not significant, the interpretation of the parameters as marginal rates of change is valid.

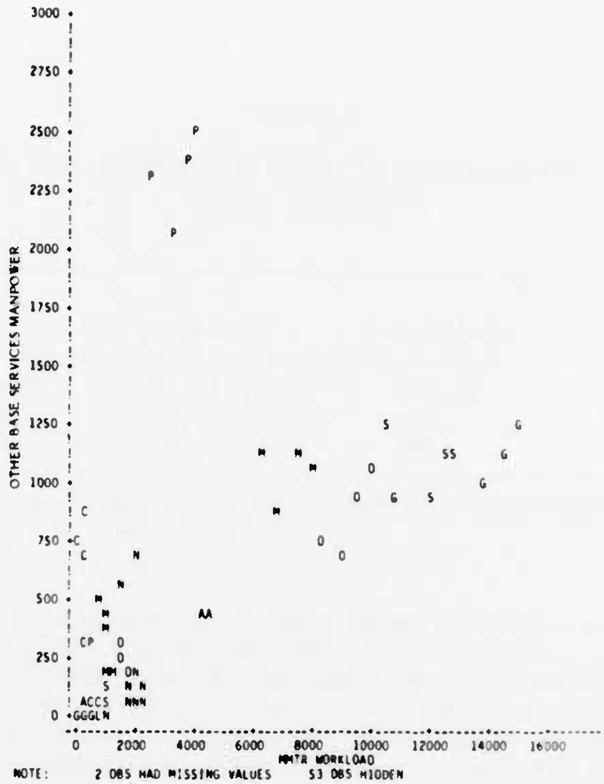

Figure 5. BOSDIFF vs. workload.

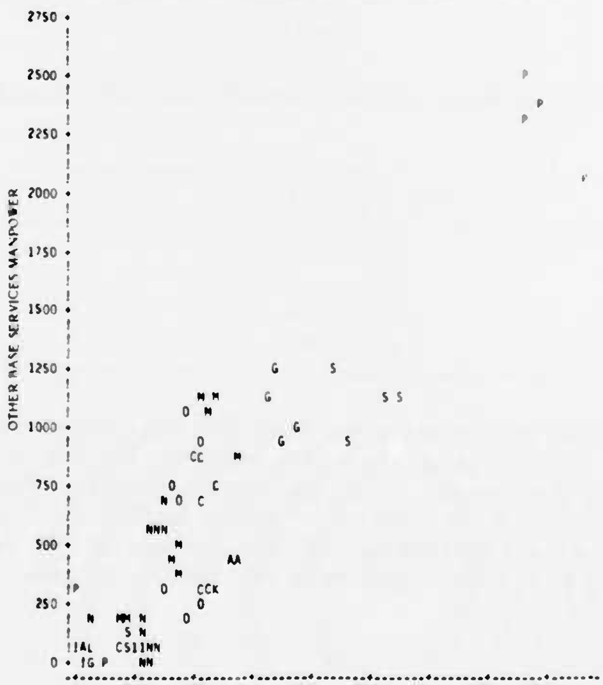

Figure 6. BOSDIFF vs. TENANT.

Table 20

Least Squares Regression of BOSDIFF With WORKLOAD and NASTEN (Overall $R^2 = .917$)

Variable	Coefficient	Std Error	t	Significance Prob t
Intercept	12.086	19.131	0.63	.5289
WORKLOAD	.086	.004	20.97	.0001
NASTEN	.394	.015	26.25	.0001

Note. NASTEN = NASFLAG $\cdot$ TENANT = $\begin{cases} \text{TENANT for naval air stations} \\ \text{0 Otherwise} \end{cases}$

Since the data set consists of pooled time series data, tests for time-dependence of the error terms were performed. The introduction of a fiscal year variable was not significant. Table 21 shows the mean residual and the mean actual values for BOSDIFF by year. While all mean residuals are not significantly different from zero, the model does fit the fiscal years 80 and 81 somewhat better than 78 and 79. Inspection of both the BOSDIFF and WORKLOAD data shows little variation across time at a given complex.

Table 21

Mean Residual and Mean Actual Values for BOSDIFF Equation By Year

FY	Mean BOSDIFF	Mean Residual
78	351	-36
79	392	+35
80	386	- 4
81	403	+ 5

Figure 7 displays the residuals for the BOSDIFF equation plotted against the facility size as measured by AREA. Again there is a tendency for the residual to increase with size but the weighted least square technique described earlier gives a worse overall fit with no major change in the coefficients of either WORKLOAD or NASTEN. Figure 8 shows the average residuals plotted against the average actual values of BOSDIFF for each location; and Figure 9, overall scatter of residuals by location.

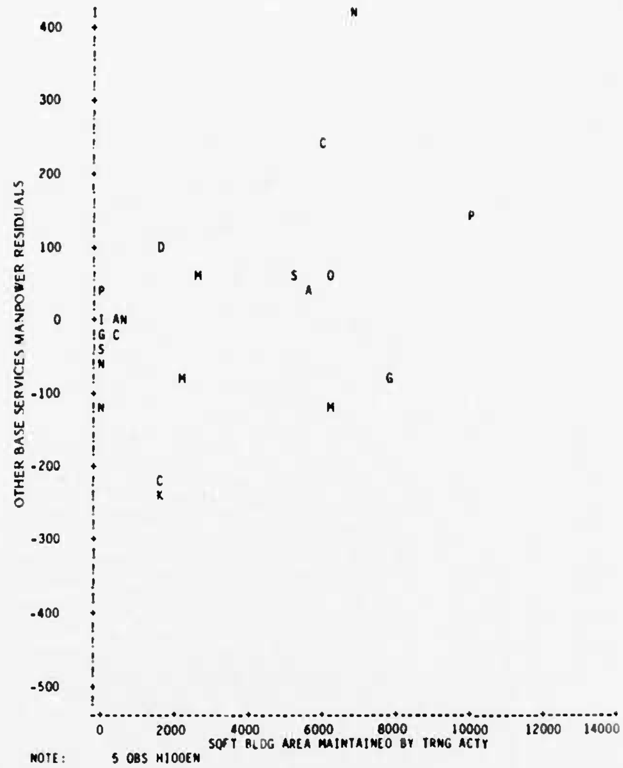

Figure 7. Residuals vs. area for BOSDIFF equation.

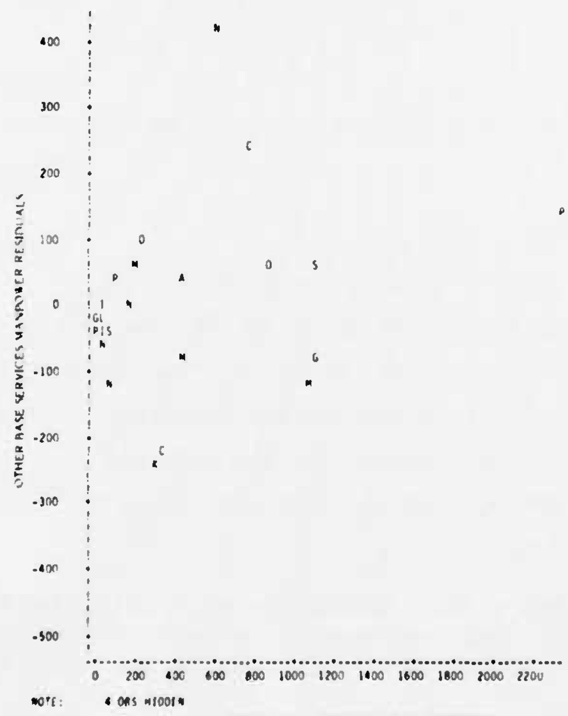

Figure 8. Residuals vs. actuals for BOSDIFF equation.

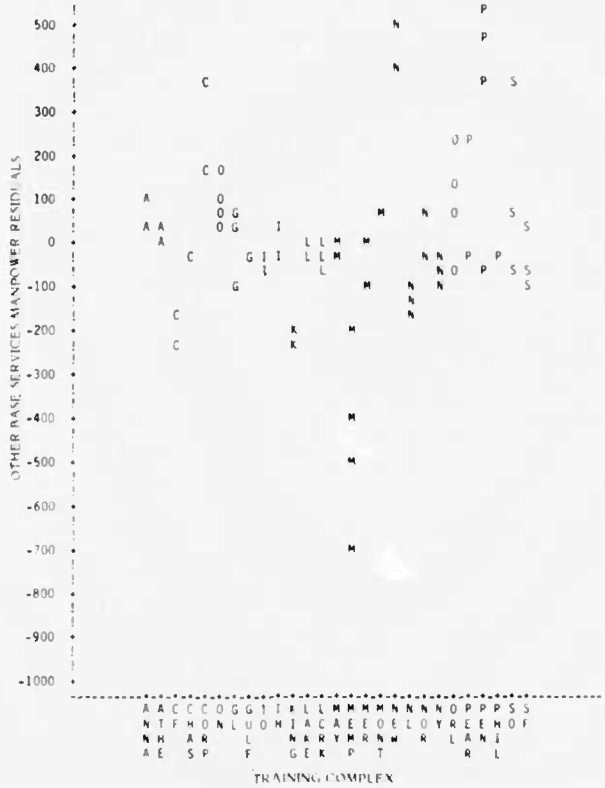

Figure 9. Residual plot for BOSDIFF regression.

The Combined TOTMP Model

The two equations displayed in Tables 15 and 20 may be combined, resulting in the predictive equation:

TOTMP = TOTRPMA + BOSDIFF

= (.066 • AREA) + (.086 • WORKLOAD) - 113.788

For Great Lakes, San Diego, Orlando (Recruit)

= (.066 • AREA) + (.086 • WORKLOAD) + (.394 • TENANT) + 21.782

For Chase Field, Corpus Christi, Kingsvile, Meridian, Memphis, and Pensacola (Air Stations), and

= (.066 • AREA) + (.086 • WORKLOAD) + 21.782

Elsewhere.

Diagnostics on the coefficients of each variable are not available for the combined model since it did not result from a single least-squares approach. Nonetheless, it is possible to calculate a "pseudo" R^2 for the TOTMP model. If, for any model of the form Y_i = f

$(X_1, ..., X_p)$, $i=1,2,..., n$ $\hat{Y}_i$ represents the predicted value of Y_i and $e_i = Y_i - \hat{Y}_i$ is the residual, then the total sum of squares of the deviations of Y from its mean,

$$\sum (Y_i - \bar{Y})^2,$$

can be decomposed:

$$\sum (Y_i - \bar{Y})^2 = \sum (Y_i - \hat{Y}_i)^2 + (\hat{Y}_i - \bar{Y})^2 + 2\sum (Y_i - \hat{Y}_i)(\hat{Y}_i - \bar{Y}).$$

If Y_i is found using least squares, the third term in the equation above vanishes to obtain

$$\sum (Y_i - \bar{Y})^2 = \sum (Y_i - \hat{Y}_i)^2 + \sum (\hat{Y}_i - Y)^2$$

or total sum squares = sum square errors + sum squares regression.

If this relationship is abbreviated as TSS = SSE + SSR, the usual R^2 statistic is then defined to be:

$$\frac{SSR}{TSS} = 1 - \frac{SSE}{TSS}.$$

In this application, the predicted value of TOTMP is not the result of least squares but, rather, of adding two least squares estimates. The third term does not vanish in this case; both

$$\frac{SSR}{TSS} \text{ and } 1 - \frac{SSE}{TSS}$$

can be computed and each represent a measure for "goodness of fit" but they are not equivalent. In fact, they are not restricted to be between 0 and 1. When these are computed for the combined model, the following values are produced:

$$\begin{aligned} TSS &= 52.45 \times 10^6 \\ SSR &= 46.18 \times 10^6 \\ SSE &= 2.27 \times 10^6. \end{aligned}$$

The two statistics are, then,

$$\frac{SSR}{TSS} = .880 \text{ and } 1 - \frac{SSE}{TSS} = .957.$$

By either measure, the overall fit is good.

When these same computations are made to check the accuracy of the prediction for BOSMP, which is the total BOS end strength with the PWC contribution removed, the values

$$\frac{SSR}{TSS} = .870 \quad \text{and} \quad 1 - \frac{SSE}{TSS} = .938$$

are obtained. The residual plot for BOSMP is shown in Figure 10.

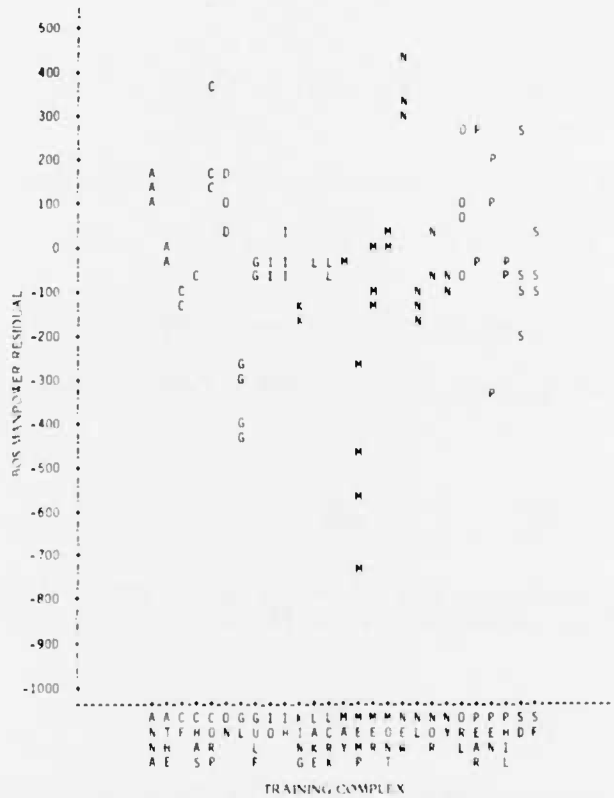

Figure 10. Residual plot for BOS manpower model.

Model Validation

One method for validating the accuracy of the model is to drop all observations for a given year, reestimate the equations, and then compare the predicted and the actual values for the missing year. The coefficients resulting from this procedure are shown in Table 22. The coefficients of WORKLOAD and NASTEN (the NAS tenant variable) show little variation over time. When the actual values are compared to the predicted for the omitted year, the results shown in Table 22 are obtained. The mean error is approximately 9 percent in predicting fiscal years 78 and 79 and only 1 percent in predicting fiscal years 80 and 81, again affirming that the model fits the latter years more accurately.

Table 22

Model Validation

Item	FY Dropped 78	79	80	81
Sensitivity of Coefficient to FY				
Intercept	3.571	8.438	15.413	20.224
WORKLOAD	.089	.084	.086	.084
NASTEN	.422	.387	.387	.382
Predicted vs. Actual Values				
Mean value of TOTMP	505	544	537	556
Mean error of estimate	-46	+47	-6	+7

Considerations in Implementation

When this model is actually implemented, it would be desirable to output the predicted value for BOSMP rather than TOTMP. Since TOTMP = BOSMP + TNGPWCMP, this amounts to subtracting the value of TNGPWCMP from the predicted TOTMP for each location receiving PWC support.

The breakdown of the total BOS end strength into the RPMA and other base services components corresponds to the five program elements shown in Table 1. The RPMA manpower is contained in PEs 85794N and 85894N; and the remaining portion, in PEs 85795N, 85796N, and 85896N. Consequently, the equations could be used separately and still yield meaningful output at the PE level. Because the model is close to 100 percent comprehensive over the set of program elements, it would readily fit into the PE/DPPC orientation of the Navy's manpower programming process. It would be difficult but not altogether impossible to output the BOS requirements by type of training. Workload is available by training type but it would be difficult to separate the BOS resources at complexes, such as Pensacola and San Diego, where multiple types of training occur.

The predictability of the tenant variable in the future raises another issue. The version of the earlier naval station/air station model that was implemented in the interactive manpower planning system (IMPS) treated the TENANT variable as constant. This would seem to be a doubtful hypothesis at training installations where a portion of the tenant end strength represents instructors and others who are directly involved in training. One would expect increased workload to result in an increased number of instructors. The problem of relating tenant population itself to student workload cannot be solved in the near term, especially since the host-tenant relationships are poorly defined.

The resources required to maintain the model depend, to some degree, on the treatment of the tenant variable and the relative priority of maintaining for display purposes a more detailed data base than the model actually requires. If the tenant population for the air stations is held constant, all that is required to minimally update the model is the yearly inclusion of both BOS training manpower by location and the projected workload data.

An enhanced version of this model would require that the facility size variable AREA be recalculated. This would be a relatively straightforward procedure, assuming there are no major revisions in the content or format of the NFADB maintained by NAVFAC. The most difficult part of the data to update is the TENANT information. Undoubtedly, the host-tenant relationships shown in Table 3 are less than accurate. To improve its accuracy, a time-consuming process would be necessary. This would be justified if the cooperation and support of other organizations within the Navy could be obtained.

CONCLUSIONS

A two-equation model that relates the total BOS manpower at training locations to facility size, student workload, and tenant population has been derived that is both statistically significant and reasonable. The two major components of BOS manpower, corresponding to real property and maintenance functions and other base services (largely personnel oriented), were modelled separately. This separation of BOS manpower was accomplished by using the NCIS activity group/subactivity group nomenclature. It is altogether reasonable that these components are driven by distinct factors.

Hudak et al. (1982) concluded that the manpower requirements at air training stations did not differ significantly from those at other air stations. This research showed that the requirements at training locations having air stations are significantly different from those at other training complexes.

RECOMMENDATIONS

The model described herein demonstrates that BOS training manpower can be related to facility size, student workload, and tenant population indicators. For these results to achieve maximum visibility and usefulness, the model should be implemented on a computer accessible to Navy planners. It would appear that the interactive manpower planning system (IMPS), which is being developed by NAVPERSRANDCEN at the Argonne National Laboratory, is an appropriate system for this implementation.

Before the implementation stage is initiated, these results should be thoroughly briefed to the potential users within OP-01 and CNET, so that their views on input/output requirements can be incorporated into the interactive model. An implementation plan and detailed functional design should then be developed and promulgated to all interested parties before the software is developed.

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By either measure, the overall fit is good.

When these same computations are made to check the accuracy of the prediction for BOSMP, which is the total BOS end strength with the PWC contribution removed, the values [illegible] years [illegible] and [illegible], again affirming that the model fits the latter years more accurately.