(12)

CRM 86-267 / December 1986

AD-A182 899

RESEARCH MEMORANDUM

A STUDY OF SELECTED ISSUES IN MILITARY CONSTRUCTION AND BASE OPERATING SUPPORT

Henry L. Eskew
Bobby Jackson
Joseph S. Domin

CNA

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SECURITY CLASSIFICATION OF THIS PAGE

ADA182899

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY	3. DISTRIBUTION / AVAILABILITY OF REPORT Approved for public release; distribution unlimited.
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	
4. PERFORMING ORGANIZATION REPORT NUMBER(S) CRM 86-267	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION Center for Naval Analyses / 6b. OFFICE SYMBOL (If applicable) CNA	7a. NAME OF MONITORING ORGANIZATION Office of the Chief of Naval Operations (OP-04)
6c. ADDRESS (City, State, and ZIP Code) 4401 Ford Avenue Alexandria, Virginia 22302-0268	7b. ADDRESS (City, State, and ZIP Code) Navy Department Washington, D.C. 20350-2000
8a. NAME OF FUNDING / ORGANIZATION Office of Naval Research / 8b. OFFICE SYMBOL (If applicable) ONR	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER N00014-87-C-0001
8c. ADDRESS (City, State, and ZIP Code) 800 North Quincy Street Arlington, Virginia 22217	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. 65154N PROJECT NO. R0148 TASK NO. WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)

A Study of Selected Issues in Military Construction and Base Operating Support

12. PERSONAL AUTHOR(S)

Henry L. Eskew, Bobby Jackson, Joseph S. Domin

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final	FROM TO	December 1986	36

16. SUPPLEMENTARY NOTATION

17. COSATI CODES

FIELD	GROUP	SUB-GROUP
05	01	
13	13	

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)

Bases (structures), BOS (Base Operating Support), ~~Construction,~~ Economic analysis, ~~Facilities,~~ ~~Investment,~~ Maintenance, Military budgets, Military facilities, Military requirements, OBOS (Other Base Operating Support), Replacement, Statistical analysis

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

This research memorandum documents a study of several related issues in the Navy's military construction and base operating support programs. Construction-related topics include: (1) changes in the stock of capital facilities over time, (2) the role of, and need for, replacement/modernization construction; (3) economic evaluation of proposed capital investments, and (4) training in economic analysis for Navy facility planners and engineers. As for base operating support, the feasibility of full-scale development of quantitative measures of performance as a basis for improving the allocation of resources to these activities was examined; results indicated that such development was not feasible. The alternative of macro-level statistical modeling appears to offer considerably greater promise.

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT ☐ UNCLASSIFIED/UNLIMITED ☒ SAME AS RPT ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE (Include Area Code) / 22c. OFFICE SYMBOL

DD FORM 1473, 84 MAR 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE

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16 January 1987

MEMORANDUM FOR DISTRIBUTION LIST

Subj: Center for Naval Analyses Research Memorandum 86-267

Encl: (1) CNA Research Memorandum 86-267, "A Study of Selected Issues in Military Construction and Base Operating Support," by Henry L. Eskew, Bobby Jackson, and Joseph S. Domin, Dec 1986

1. This research memorandum represents the final documentation of a CNA project requested by the Director, Shore Activities Planning and Programming Division (OP-44). It documents a study of several different but related issues in the Navy's military construction and base operating support programs. Construction-related topics include: (1) changes in the stock of capital facilities over time; (2) the role of, and need for, replacement/modernization construction; (3) economic evaluation of proposed capital investments; and (4) training in economic analysis for Navy facility planners and engineers. As for base operating support, the study examined the feasibility of full-scale development of quantitative measures of performance as a basis for improving the allocation of resources to these activities. CNA concluded that such development was not feasible, although the alternative of macro-level statistical modeling appears to offer considerably greater promise.

2. Enclosure (1) is forwarded as a matter of possible interest.

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Distribution List:
OP-04
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OP-442E (10 copies)

CRM 86-267 / December 1986

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ABSTRACT

This research memorandum documents a study of several related issues in the Navy's military construction and base operating support programs. Construction-related topics include: (1) changes in the stock of capital facilities over time; (2) the role of, and need for, replacement/modernization construction; (3) economic evaluation of proposed capital investments; and (4) training in economic analysis for Navy facility planners and engineers. As for base operating support, the feasibility of full-scale development of quantitative measures of performance as a basis for improving the allocation of resources to these activities was examined; results indicated that such development was not feasible. The alternative of macro-level statistical modeling appears to offer considerably greater promise.

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SECTION 1

INTRODUCTION

In October 1985, the Director, Shore Activities Planning and Programming Division (OP-44), approved an analysis plan [1] under which the Center for Naval Analyses (CNA) would conduct a study of several issues bearing on functions assigned to OP-44. The following tasks were undertaken in the study:

- Review of the size and age distribution of the Navy's stock of capital facilities, with emphasis on the demand for, and history of, military construction carried out for purposes of replacing or modernizing existing facilities

- Study of the set of activities--including retail supply operations, bachelor housing, automated data-processing services, administration--that make up the activity group known as Other Base Operating Support (OBOS), with emphasis on the identification of quantitative performance measures and predictors of funding requirements for those activities

- Analysis of the nature and uses, both present and potential, of data reported annually on the readiness of Navy shore base facilities

- Development of a statistical model for forecasting the nondeferable backlog of facility maintenance and repair requirements for the years included in each Program Objective Memorandum (POM).

This research memorandum reports on the first and second of the above tasks. The third task is documented in [2]. Documentation of the final task has been deferred until data from FY 1986 can be obtained and analyzed.

SECTION 2

CAPITAL FACILITIES: AGING, REPLACEMENT, AND CHANGE OVER TIME

During development of the POM, OP-44 assesses the military construction requirements of resource sponsors on the staff of the Chief of Naval Operations (CNO) and influences the allocation of funds among sponsors.[1] Recently there has been growing interest in construction undertaken to replace or modernize existing facilities and in the full cost implications of such construction. New construction of any type alters the Navy's stock of capital facilities; it also alters the age distribution of that stock. Replacement/modernization construction has, in addition, a significant impact on budget requirements for facility maintenance and repair. It is not uncommon that the savings which result from such a project are of sufficient magnitude and duration to offset the project's construction costs. Naturally such savings must be properly identified and quantified during the planning process, with allowance made for the fact that time profiles of savings and investment outlays differ significantly. In short, an economic analysis of proposed capital investments is required.

Even if the economic viability of a project can be demonstrated, the project must nevertheless compete for available funds--funds which are closely scuntinized, and ultimately determined, by the Congress--with a vast array of other projects, many of which are perceived as having higher priority mission justifications. These considerations taken together give rise to a number of questions:

- What has happened to the Navy's stock of capital facilities over time, and what has been the role of replacement/modernization construction?

- What are the present indicators of the need for replacement/modernization construction?

- What criteria are used within the Navy for evaluating proposed capital investments, and how do they relate to investment criteria used elsewhere?

- What can be said about the status of training in economic analysis for Navy facility planners and engineers?

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1. Resource sponsors consist of the Vice CNO; the Deputy CNOs for Manpower, Personnel and Training, Submarine Warfare, Surface Warfare, Logistics, and Air Warfare; and the Offices of Naval Warfare, Naval Medicine, and Command and Control.

CNA's efforts to provide answers to these questions and to gain insight into other related matters are documented in the remainder of this section.

CONSTRUCTION AND CAPITAL STOCK OVER TIME

To provide a quantitative perspective on the issues at hand, statistical time series on Navy military construction and the stock of capital facilities were compiled. The data are shown in table 1. The measure of capital stock used is current plant value (CPV), defined in [3] as:

> ...a computer generated dollar estimate which is used as an indicator of replacement cost for a Class 2 facility. This is an estimate of replacing a facility with an identical facility under identical circumstances in the same location but at current labor, material and equipment cost rates.

The data in the table reflect what appears to be a fundamental contradiction: although the construction program has averaged well over $1 billion per year (constant dollars), total facility CPV has been relatively constant since FY 1978. A closer look at these and related data provided an explanation of the apparent contradiction; namely, the Navy disposes of a substantial amount of capital facilities each year, either through outright demolition or by various types of administrative transfers. For the period FY 1980-1985, dispositions averaged roughly $1.2 billion annually (constant FY 1985 dollars).[1] It comes as no surprise, then, that little change has occurred in the total stock over the last several years. Were it not for these dispositions of older facilities, the stock would be aging at an even faster rate than is now being experienced. The subject of facility age is discussed in more detail below.

FACILITY AGE AND REPLACEMENT/MODERNIZATION INVESTMENT

Data maintained in NAVFAC's Naval Facility Assets Data Base (NFADB) permit construction of an age profile of the capital stock, segmented by source of funding. The profile as of the end of FY 1985 is presented in table 2, indicating that the average age of a typical facility is over 40 years.

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1. Data on facility dispositions are provided in the Naval Facilities Engineering Command (NAVFAC) P-319 series reports and served as the basis for this computation.

TABLE 1

MILITARY CONSTRUCTION, NAVY AND NAVY RESERVE, AND CAPITAL FACILITY CURRENT PLANT VALUE (CPV)[a]
(billions of FY 1985 dollars)

Fiscal year	MCON[b]	MCNR[c]	Facility CPV
1985	1.535	0.061	75.878
1984	1.283	0.032	75.438
1983	1.171	0.027	75.034
1982	1.630	0.040	74.573
1981	0.944	0.039	75.013
1980	0.736	0.023	74.793
1979	1.119	0.032	75.233
1978	0.796	0.033	75.014
1977	1.090	0.039	70.033
1976	1.170	0.063	73.899
1975	1.012	0.040	74.696
1974	1.156	0.045	72.291
1973	1.087	0.046	68.564
1972	0.892	0.026	71.617
1971	0.822	0.013	65.693

SOURCE: Data for the construction appropriations appear in Historical Budget Data, published annually by the Department of the Navy Comptroller. They were escalated to an FY 1985 base by use of indices in [4]. The CPV information was obtained from the NAVFAC annual P-319 series reports. Price indices developed by Marshall Swift and Company and provided to CNA by NAVFAC (Code 1003) were used to convert the CPV data to an FY 1985 base.

a. Facility CPV excludes land, Marine Corps, and family housing.
b. Military Construction, Navy.
c. Military Construction, Navy Reserve.

TABLE 2

AVERAGE AGE AND PERCENTAGE OF TOTAL FACILITY CPV
BY FUNDING SOURCE, FY 1985

Funding source	Average age (yrs)[a]	Percent of total CPV
Operation and Maintenance, Navy (O&MN)	37.1	58.1
Navy Industrial Fund (NIF)	45.9	31.6
Operation and Maintenance, Navy Reserve (O&MNR)	37.2	2.8
Research, Development, Test and Evaluation (RDT&E)	36.7	2.8
Other	41.3	4.7
	40.2	100.0

SOURCE: NAVFAC, Naval Facility Assets Data Base.

a. These are weighted averages, with individual facility CPV serving as the weights. The average for the column as a whole is weighted by percent of total CPV for each fund source.

The same underlying data can also be arranged in such a way as to portray the percentage of total CPV constructed during successive intervals of time (e.g., 1935-1939, 1940-1944, 1945-1949). When this is done, the results are more striking: two-thirds of the total capital stock was acquired during or before World War II.[1]

Two additional items of information help bring the issue of facility age and its relation with replacement/modernization construction requirements into focus. First, during 1984 and 1985 the Chief of Naval Education and Training (CNET) conducted a detailed engineering evaluation of all facilities in that command that had exceeded 125 percent of the commercial useful-life standard for similar facilities. One-fourth of those were found to be beyond the point where they could be restored to satisfactory condition through the use of maintenance (O&M,N) funds. In other words, construction activity was called for. The dollar amount of the requirement was on the order of $500 million.[2] Extrapolation of

1. These computations were carried out and reported by NAVFAC (Code 203).
2. These results were reported at a CNO Executive Board meeting in March 1986 which focused on the condition of Navy shore base facilities.

those results Navy-wide suggests there is more than $8 billion of CPV that is either now or soon to be in need of replacement.

Second, CNA conducted a statistical regression analysis that also focused on CNET. A model was formulated in which the dependent variable was average annual facility maintenance and repair costs over a four-year period. This variable was regressed on facility age and CPV, the latter to control for size. Cost data were obtained from the Navy Cost Information System (NCIS), FY 1981-1984. Age and CPV data were taken from the NFADB discussed earlier. Results were as follows:

$$\hat{M} = -\ 609.75 + \underset{(1.60)}{30.78A} + \underset{(7.01)}{0.0091P}$$

$$N = 29 \qquad \bar{M} = 1530.7$$

$$R^2 = 0.740 \qquad \bar{A} = 32.1$$

$$F = 36.92 \qquad \bar{P} = 126{,}958.9\ ,$$

where

M = four-year average annual maintenance and repair costs, thousands of FY 1984 dollars

A = weighted average age of facilities within a unit identification code (UIC), years

P = current plant value, thousands of FY 1984 dollars, within UIC.

Numbers in parentheses are t ratios, indicating that the coefficient on the age variable is statistically significant at better than the 0.10 level (one-tail test). Its value suggests that each additional year of age leads to an increase in a facility's annual maintenance and repair costs of some $30 thousand for the cross-section of facilities examined. The elasticity of cost with respect to age, computed at the sample means of the variables, is

$$\text{Elasticity} = \frac{\partial C}{\partial A} \cdot \frac{\bar{A}}{\bar{C}} = \frac{30.78(32.1)}{1570.1} = 0.645\ .$$

In words, this means that a 10-percent increase in age leads to a more than 6-percent increase in cost. The elasticity of cost with respect to facility size as measured by CPV is only slightly higher (0.755).

The foregoing indicators of the extent and implications of aged facilities can be thought of as characterizing, at least in some rough sense, the demand for replacement/modernization construction. To what extent has that demand been met? Data made available by NAVFAC (Code 211) indicate that, at most, one-third of annual military construction is for purposes of replacement or modernization. That statistic, which is on the order of $350 million (FY 1985 dollars), can best be put in perspective by comparison with the total CPV at the end of 1985, $75.9 billion. Those two numbers together imply a replacement cycle length of more than 200 years. An unavoidable conclusion is that relatively few resources are being made available for the replacement and modernization of the Navy's stock of capital facilities, two-thirds of which was constructed during or before World War II.

EVALUATION CRITERIA FOR CAPITAL INVESTMENTS

Two important factors tending to inhibit replacement/modernization projects have been mentioned previously: the role of Congress in review and authorization of all military construction, and the high priorities assigned to construction associated with new mission requirements and expansion of existing missions. Nevertheless, it is relevant to inquire--as CNA was asked to do--into (1) how the Navy evaluates potential projects whose justifications are largely economic; (2) whether such evaluations influence the selection of projects for funding; and (3) what types of evaluation criteria are in use outside the Navy. A discussion of these issues follows.

Evaluation and justification in the Department of Defense of all major construction projects, as well as other investments, must be carried out in accordance with OMB circulars [6, 7], which are further promulgated by DOD and SECNAV instructions [8, 9]. From time to time, additional guidance is provided in the form of implementing instructions. Particularly important in the Navy is the instruction pertaining to preparation of savings-to-investment ratios (SIRs) in connection with what are known as "Quick SIR" evaluations.

Quick SIR is a preliminary submission of a simplified economic analysis. It is required for all replacement, modernization, or expansion projects except those undertaken for health, safety, fire, pollution, or security reasons. Constant-dollar estimates of costs and benefits (savings) are developed, and the SIR statistic is computed by dividing the project's construction cost into the present value of the time stream of savings discounted at a rate of 10 percent in accordance with OMB guidance. Projects are ranked by their SIR values and recommended to resource sponsors on that basis.

Table 3 summarizes the results of the first two Quick SIR submissions made in November 1983 and November 1984. The 191 projects submitted had an average SIR value of 2.25. More than 60 percent of the projects, however, have either not been programmed for funding or, if programmed, were not until after FY 1988. Further, there appears to be a negative correlation between the economic worth of projects (as measured by their SIR values) and the funding priorities allocated to them. It would seem then that the outcome of economic evaluations has had little influence on funding decisions.

TABLE 3

STATUS OF PROJECTS INCLUDED IN QUICK SIR SUBMISSIONS OF NOVEMBER 1983 AND NOVEMBER 1984

Program year	Number of projects	Average SIR	Cumulative percent of projects
FY 1986	11	1.97	6
FY 1987	26	1.98	19
FY 1988	38	2.03	39
FY 1989	31	2.14	55
FY 1990	15	2.54	63
FY 1991	8	6.79[a]	68
Unprogrammed	62	1.96	100
	191	2.25	

SOURCE: NAVFAC (Code 203).

a. Artificially high because of one project with a SIR of 40.64.

Turning to the question of how potential capital investments are evaluated outside the Navy and DOD, a recent survey by the Conference Board [5] provides several useful insights. Questionnaires concerning techniques used to evaluate and select capital investment alternatives were completed by 125 corporate officials representing 95 manufacturing and 30 nonmanufacturing firms. More than 80 percent of the respondents reported the use of "hurdle rates," that is, minimum rates of return that candidate projects must provide in order to qualify for funding. In most cases, the specific measure used was the internal rate of return (IRR). This is the discount rate that, when applied to the stream of net savings and other monetary benefits, equates the stream to the project's initial costs.[1] The rate most frequently used was 15 percent, with no adjustment made for inflation. Assuming 5 percent annual

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1. For completeness it should be noted that problems can arise in computing an IRR. Strictly speaking, the rate is found by solving a polynomial equation of degree n. Such an equation will, in general, have n solutions, not all of which need be the same. Provided, however, the stream of benefits is "well behaved"--that is, first negative and then positive--no problem should arise.

inflation, the 15-percent IRR equates to a 10-percent rate in real terms. A 10-percent real IRR is thus, by definition, the same as a SIR of 1.0. It follows that a one-for-one mapping exists between IRR and SIR rates. For example, the 2.25 average SIR value shown in table 3 equates to an IRR of 32 percent.[1] What may be concluded is that no conceptual difference exists between the "hurdle rate" used by the Navy--a SIR of 1.0 or higher--and the 10-percent real IRR preferred in the private sector.

TRAINING IN ECONOMIC ANALYSIS

Meaningful economic analysis of proposed construction projects involves considerably more than computation of savings-to-investment ratios. Other relevant considerations include

- Statistical estimation methods
- Risk and uncertainty assessment
- Sensitivity analysis
- Fixed vs. variable costs
- Price escalation indices
- Outlay profiles
- Mathematics of finance
- Computer models and applications.

In light of the crucial link between economic analysis and replacement/modernization construction, CNA was asked to review the training in economic analysis presently provided to naval facility planners and engineers. The following paragraphs highlight the findings and recommendations of that review.

The Naval School for Civil Engineering Corps Officers, Port Hueneme, California, offers a one-week course in economic analysis to approximately 100 Navy and Marine Corps personnel each year.[2] This course is the primary vehicle for training junior officers and civilians in performing and documenting economic analyses that support major

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1. A standard part of the Quick SIR procedure is that savings are assumed to span a period of 25 years. It is for that reason that the conversion from SIR to IRR can be made without further information about a project or group of projects.
2. A five-hour segment in fundamentals of economic analysis is also provided to students in the basic course.

construction projects. Class materials, reference documents, and instruction, all of which adhere closely to OMB and DOD guidance, appear to be of very high quality and are also quite similar to those found in the economic analysis course offered by the Army Corps of Engineers. There is, however, one notable exception, which will be discussed momentarily.

The above notwithstanding, certain concerns over the course's long-term effectiveness appear warranted. These have to do with the ability of a junior officer or civilian to implement the course's content upon return to a field assignment. Because the typical student has little prior background in these matters, retention levels decline rapidly. Personnel in the field need simple tools and devices that would help produce quick results without the necessity for "relearning" present-value concepts, statistical estimation methods, risk/uncertainty calculations, etc., or for choosing among alternative output formats, investment performance measures, and price escalation indices.

A promising approach to satisfying these requirements would be to incorporate into the course, as the Corps of Engineers has done, a set of highly standardized and computer-assisted economic analysis and reporting procedures. An important feature of such a package, which would include step-by-step instructional material for classroom practice and future reference, is that its output could be automatically incorporated into DD-1391 report format which is required for all proposed construction projects. The computational medium used by the Corps is a network of time-shared mainframes, but the convenience, economy, and widespread availability of personal computers suggests that they might be a preferable alternative. In either case, the "benefit-cost" ratio is likely to be high.

SECTION 3

OTHER BASE OPERATING SUPPORT

In addition to its planning and programming functions relating to military construction, OP-44 has similar responsibilities for the diverse mix of activities classified as base operating support (BOS). Within that classification are two major activity groups (AGs): maintenance and repair of real property (MRRP) and other base operating support (OBOS). These two AGs, in turn, consist of a number of subactivity groups (SAGs). The complete hierarchical structure, together with funding data for FY 1985, is shown in table 4.[1]

As indicated in the table, the OBOS total exceeds $2 billion and is more than twice that of MRRP. However, unlike MRRP where the consequences of funding decisions can be reckoned in terms of facility readiness ratings and changes in the backlog of maintenance and repair, OBOS activities have not proved to be analytically tractable. CNA sought to determine whether this was simply because the set of functions is so large and heterogeneous or whether the problem results from insufficient analytical attention.

The study of OBOS was conducted along two different lines:

- Development of quantitative measures of performance
- Statistical analysis of macro-level predictors of OBOS funding requirements.

Documentation of the study results follows the same division.

MEASURES OF PERFORMANCE

The primary objective of this portion of work was to identify a manageable number of quantitative measures of performance for which data could be collected and reported through the existing financial management system and which also would satisfy two programming and budgeting needs. The first need was to provide an indication of "how well" OBOS functions are currently being performed; the second was to improve the basis for allocation or reallocation of available OBOS funds, especially as aggregate funding targets change throughout the programming and budgeting process.

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1. The structure reflected in the table is consistent with the Navy's internal financial accounting system. To satisfy OSD requirements, however, the same data will sometimes be arranged differently; that is, the SAGs covering operation of utilities and other engineering support (F3FC and F3FD) are combined with MRRP to form a group called real property maintenance activities (RPMA).

TABLE 4

BASE OPERATING SUPPORT SUBACTIVITY GROUPS AND FUNDING FOR FY 1985[a]

Subactivity group	Identifier	Funding ($ millions)	Percent of total
Maintenance and repair of real property	F4FA	865.9	88.4
Minor construction	F4FB	113.9	11.6
MRRP total		979.8	100.0
Operation of utilities	F3FC	455.5	20.2
Other engineering support	F3FD	315.8	14.0
Administration	F3FF	369.7	16.4
Retail supply operations	F3FG	201.4	8.9
Other base services	F3FR	280.4	12.4
Aircraft operations and maintenance	--[b]	4.9	0.2
Hazardous waste	F3FT	5.6	0.3
Installation equipment maintenance	F3FH	85.1	3.8
Bachelor housing	F3FJ	52.7	2.3
Payments to GSA	F3FE	74.2	3.3
Morale welfare and recreation	F3FL	75.4	3.3
Other personnel support	F3FK	94.0	4.2
Audiovisual	F3V2	11.5	0.5
Automatic data processing	F3FQ	99.9	4.4
Base communications	F3FN	97.2	4.3
NATO	F3F5	19.3	0.9
Physical security	F3FV	8.0	0.4
Medical/dental support	F3FM	3.0	0.1
Human goals	F3L2	1.8	0.1
OBOS total		2,255.4	100.0

SOURCE: NAVFAC (Code 1003).

a. Data reflect budget execution in FY 1985.
b. This entry combines multiple SAGs.

As the information in table 4 reveals, nearly three-fourths of OBOS funds are centered in five subactivity groups:

- Operation of Utilities
- Other Engineering Support
- Administration
- Retail Supply Operations
- Other Base Services.

Consequently, a decision was made to concentrate on only those five and in fact to conduct "case studies" of two of the five--Administration and Retail Supply Operations. Before undertaking the case studies, however, a literature review was conducted, focusing on the general methodology of performance measurement and on applications in functional areas that have a close analog in OBOS. Certain concepts and examples in the literature are especially germane to what follows and therefore warrant reporting in summary form.

Literature Review[1]

Performance measures can be of thre pes:

- Measures of effectiveness
- Measures of efficiency
- Measures of workload performed.

Each serves a different purpose, although the three are interrelated.

Effectiveness measures show the extent to which goals and objectives are being achieved--they answer the "How well?" question. Fundamental to effectiveness measurement, of course, is agreement over what constitutes favorable or successful performance.

Measures of efficiency relate quantity of output to the quantity of inputs required for production. Efficiency measures include the following types:

- Output-input ratios with workload data as the unit of output

1. Material in this section is drawn from [10, 11, 12, 13, 14, 15, 16, 17, 18].

- Output-input ratios with effectiveness data as the unit of output

- Equipment and personnel utilization rates

- Combinations of the above

- Measures of relative change (productivity indices).

Finally, measures of workload performed capture the amount of work done and also interact with the efficiency measures indicated above. Representative examples of effectiveness, efficiency, and workload measures in the functional areas of transportation, fire protection, and water supply operations are shown in table 5.

Criteria to be considered in selecting performance measures and identifying their associated data requirements are as follows:

- Appropriateness and validity. Does the measure relate to the objective for that activity, and does it measure the degree to which a user's need is met?

- Uniqueness. Does it measure some characteristic that is uncaptured by another measure?

- Completeness. Does it include most, if not all, objectives?

- Comprehensibility. Can the measure be understood?

- Controllability. Does the provider have responsibility for and control over the condition measured?

- Cost. Are cost and manpower requirements for data collection reasonable?

- Accuracy and Reliability. Is it possible to obtain sufficiently accurate and reliable information?

Certain key limitations are inherent in the use of performance measures. First is that as the complexity of the activity in question increases, the number of goals and objectives associated with it also increases. That, in turn, increases the number of relevant performance measures to the point where administrative costs (of data collection and analysis) and "information overload" can become critical problems.

A second limitation pertains to the adequacy of existing information. Some crucial aspects of effectiveness and efficiency can be best measured, and sometimes only measured, by special methods (surveys and sampling studies, for example) or by technical or sensitive data to which there is no access.

TABLE 5

EXAMPLES OF EFFECTIVENESS, EFFICIENCY, AND WORKLOAD MEASURES

	Functional area		
	Transport	Fire protection	Water supply
Effectiveness measures	Reliability: percent of trips completed on schedule	Responsiveness: percent of response times below x minutes	Quality: percent of hydrants meeting static-pressure standards
Efficiency measures	Passengers served per $1000 of operating costs	Fires prosecuted per $1000 of operating costs	Gallons treated per $1000 of operating costs
Workload measures	Passengers served per quarter	Residential fires reported per year	Hours operating per month

Finally, and perhaps of greatest importance, is the frequent inability of performance measures to meaningfully compare organizations engaged in the same activity but exhibiting differences in operating characteristics and environmental conditions. Examples of the former in the case of, say, waste collection include differences in the use of separation techniques (recycling or incineration), types of materials collected, collection frequency, crew size, form of pickups, and route-task balance. Environmental conditions tend to be more global in nature and largely beyond the control of those whose performance is being measured. Examples are differences in access to markets, geography, infrastructure, and tradition. The importance of each of these limitations cannot be overemphasized.

Shore Required Operational Capability (SHOROC)

As a preface to the two case studies, an overview of the Navy's Shore Required Operational Capability (SHOROC) system will be useful. Delineation of functions and quantification of work-related factors in SHOROC has relevance in the search for OBOS performance measures.

SHOROC is a system that uses structured functional statements to define the tasks that make up the Navy's shore activities. It also provides a framework within which staffing standards are developed and implemented. The SHOROC hierarchical structure consists of four levels:

- Mission area--the highest generalized level of designating a work assignment

- Functional area--a group of homogenous tasks within a mission area that forms a functional work center irrespective of organizational structure

- Required functional capability (RFC)--a specific task to be accomplished which contributes to the performance of the required function

- Parameter--a specified quantity, frequency, duration, etc., for an RFC.

A mission area consists of two or more functional areas, which in turn include from one to several hundred RFCs. An RFC for which a staffing standard exists may have from one to six associated parameters. An example of the four levels is:

Mission area:	Supply
Functional area:	Ancillary supply services
Required functional capability:	Enlisted dining facility operation

Parameters: (1) Number of rations served per month
(2) Number of serving lines operated per week

Numerical values of the parameters--9,100 rations per month and 21 serving lines per week, for example--serve as the basis for determining the staffing authorization for a given activity. (The vehicle used for computing the authorization is typically a fitted regression equation with SHOROC "parameters" included as predictor variables.)

SHOROC has potential utility in the development of OBOS performance measures for two reasons. First, it can provide delineation and definition of the functions included in the different subactivity groups. Second, the list of SHOROC parameters constitutes a set of performance-measure building blocks. At the same time, however, it should be noted that the parameters are only building blocks in that they capture neither effectiveness nor efficiency. They are, at best, measures of workload performed and in many cases represent indirect or surrogate quantifications that have simply exhibited empirical relationships with staffing levels.

Case Study 1: Administration

Just as the OBOS activity group encompasses a diverse mix of support functions, its second largest subactivity group, Administration, is equally heterogeneous. It consists of the following:

- Command Direction
- Management Engineering and Industrial Management
- Comptroller Services
- Civilian Manpower Management
- Military Personnel Management
- Administrative Office Services
- Word Processing
- Dependent Schools
- Personnel Planning Functions
- Miscellaneous Services and Functions
- Shore Base Activation.

Rather than having a single, direct counterpart among SHOROC mission areas, Administration spans two such areas, Inter/Intra Command Support (ICS) and Financial Services (FIN). Those mission areas encompass some 30 functional areas. ICS includes the provision of specialized services and clerical support within a command and to other activities; FIN consists of financial planning, programming, budgeting, accounting, disbursing, and performance analysis. Functional areas included in each are shown in table 6.

A numerical count drawn from [19] reveals more than 200 RFCs within the 29 functional areas in the Administration subactivity group. Recalling from the SHOROC overview that (1) quantitative measurement occurs at the RFC level and (2) an RFC may have as many as six parameters, the full dimensions of the problem become all too evident. Simply stated, there are so many different types of base operating support tasks grouped under "Administration" that even in the absence of varying operating characteristics and environmental conditions, the information overload and administrative cost problems--reference the earlier literature review--appear insurmountable. Undoubtedly it would be possible to develop a manageable number of efficiency measures for a few of the more production-oriented functions such as printing and centralized pay services, but how much progress would that represent toward meeting the original objectives? First, as a fraction of the overall Administration subactivity group, those functions would probably be close to negligible. Second, development of the efficiency measures would not address the "How well?" question, which is significantly more difficult and more important. Finally, considerable uncertainty would remain over whether meaningful comparisons could be made from such measures, however they might be aggregated. There was little basis for optimism in the results of this case study.

Case Study 2: Retail Supply Operations

Retail Supply Operations (RSO) constitute a vital function at most bases and stations. Unlike Administration, RSO falls under a single SHOROC mission area, Supply. Applicable functional areas are:

- Mission Area Support
- Inventory Control
- Material Handling
- Aviation Supply Support
- Ancillary Supply
- Contract Administration
- Specialized Navy Supply Support and Management

TABLE 6

SHOROC MISSION AND FUNCTIONAL AREAS WITHIN THE ADMINISTRATION SUBACTIVITY GROUP

Mission area	Functional area
Inter/Intra Command Support	- Mission Area Support Services - Legal Service - Public Affairs Program - Navy Patent Program - Religious Program and Consultation - Safety Programs - Management Assistance - Administrative Support Services - Command Master Chief Petty Officer - Library Services - 3-M Program Support - Music Program - Audio/Visual Services - Command and Control of a Shore Staff - Manpower Management - Centralized Personnel Distribution Management and Assignment - Naval Postal System - Printing Services - Historical Services
Financial Services	- Field Activity/Staff Mission Area Support Services - Field Activity/Staff Budgets - Activity/Staff Accounting Services - Disbursing Services - Centralized Navy Pay Services - Navy Industrial Funded Financial Services - Management Headquarters Mission Area Support Services - Management Headquarters Programs and Budgets - Management Headquarters Accounting Services - Management Headquarters Disbursing Services

- Procurement
- Traffic/Freight Terminal Services
- Petroleum Products and Services
- Sealift Transportation Management, Planning, and Control.

Despite the single mission area and fewer functional areas, there are even more RFCs in this subactivity group than in Administration (the total is close to 300). The following is a representative set of RFCs within a representative functional area (Inventory Control):

- Stock Control
- Requirements Services
- Receipt Control
- Technical Services
- Issue Control
- Customer Services
- Inventory Control Services Management.

Some of the RFCs are unique to:

- Navy supply centers and depots
- Navy shipyards
- Standard supply and fiscal departments
- Limited supply functions.

Others are common to all.

Retail Supply abounds with quantitative measures of output such as average number of line items inventoried monthly, average number of requisitions processed monthly, average number of prime contracts administered per year, and average number of cargo bookings processed per year. In addition, some limited progress has been made in developing effectiveness measures relating, for example, to timeliness of requisition response and accuracy of inventory control. Nevertheless, the situation here is very nearly the same as with Administration. A close inspection of what are useful aggregations for fiscal purposes reveals literally hundreds of different tasks carried out, some susceptible to output measurement, but virtually none whose effectiveness can be quantified unambiguously. Thus, although Retail Supply might appear at first glance to be an "easier" area for performance measurement, results of this examination were no more promising than those from the preceding one.

Summary and Conclusion

The work that began as an effort to develop performance measures for the major components of OBOS gradually evolved into a study of the feasibility of that objective. Results of the literature review pointed to fundamental differences among types of performance measures and, more importantly, identified certain limitations--"pitfalls" may be a better characterization--that were likely to be encountered.

Results of the case studies catalogued and quantified the very large and heterogeneous mix of tasks carried out under single subactivity groups. Although measures of output for a substantial portion of the tasks have been developed through SHOROC, little if any basis exists for progressing from those to measures of effectiveness. Even if a number of effectiveness measures were available--as in the case of Retail Supply, for example--it is doubtful that the requisite data for implementation are routinely available. It is even more doubtful that the conceptual and administrative problems associated with weighting, aggregating, and processing such data could be adequately resolved.

Finally, imagining that all the preceding difficulties could somehow be set aside, serious questions remain as to how meaningful or reliable comparisons of OBOS performance measures are at any given level of aggregation. (Performance measures can only influence programming and budgeting actions through comparisons of values among competing recipients.) At the lowest level, for example, a contractor-operated "fuel farm" at one base may be more effective and also more efficient than another farm where the operation is in-house, but tactical or geographic considerations may preclude contractor operations at the latter. At the other extreme, centralized pay services may be more effective but less efficient within one claimant than another, both owing to differences in available ADP resources. (Reference the earlier discussion of variations in operating characteristics and environmental conditions.)

To conclude, there appears to be almost no prospect of achieving a major improvement in the OBOS programming and budgeting process through development of a bottom-up performance measurement system. The final phase of this portion of the study for OP-44 therefore investigated the merits of certain top-down statistical approaches.

MACRO-LEVEL PREDICTORS OF FUNDING REQUIREMENTS

In a study conducted by CNA several years ago [20], statistical regression methods were used to relate total spending for base operating support (at each base in a cross-section of bases) to such variables as the number of military and civilian personnel at the base, the size of the base as measured by total acreage and building area, and the base's energy consumption. In addition to providing insights into the relative importance of different determinants of BOS costs, results of this work had applicability to questions of whether consolidation of bases would reduce aggregate BOS costs and whether BOS funds are being wisely allocated among existing bases. Nevertheless, direct application of that work in the present context was prohibited by two considerations:

- The statistical relationships focused on the sum of all BOS activities, whereas interest here is on individual subactivity groups within the OBOS activity group.

- Results applicable to individual bases are too disaggregated for the types of programming and budgeting analyses that are conducted at the headquarters level.

Consequently, a somewhat different approach was examined in this study. Data for a selected number of OBOS subactivity groups were compiled at the major claimant level for FY 1984 and FY 1985. (This is known technically as "pooling" cross-section and time-series data.) The complete list of claimants consisted of the following:

- LANTFLT
- PACFLT
- NAVEUR
- CNO
- NAVSEA
- NAVSUP
- NAVAIR
- SPAWAR
- NAVFAC
- SSPO
- MEDCOM
- NMPC
- AAUSN
- OCEANNAV
- NAVTELCOM
- CNET.

For some subactivity groups, certain smaller claimants reported no costs and were excluded from the regressions.

Depending on the nature of the subactivity group, one or more of the same types of variables included in the earlier work were examined as predictors of funding requirements. Values of the variables represented aggregations across all activities within each claimant for each fiscal year. Results of the analyses of a representative set of subactivity groups are discussed below. These results, however, should be considered more as feasibility tests than as a comprehensive and final set of empirical findings.

Administration

Based on the preceding description of functions included in Administration, it is reasonable to postulate that the number of personnel served is the primary driver of funding requirements. Two measures of personnel, military alone and military plus civilian, were examined. The former proved superior on statistical grounds. Results were as follows:

$$\hat{A} = 13{,}446.3 + \underset{(6.41)}{0.369M}$$

$$N = 26 \qquad \bar{A} = 27{,}960$$

$$R^2 = 0.631 \qquad \bar{M} = 39{,}300$$

$$F = 41.1 \qquad S.E.E. = 17{,}837 \quad ,$$

where

A = annual funding by claimant for the administration subactivity group, in thousands of FY 1985 dollars

M = military personnel end-strength, officers plus enlistees, by claimant.

These results might be termed "fair." There is a highly significant relationship between the two variables, with the coefficient for M indicating that an end-strength change of 1,000 military personnel would lead to an administration funding requirement change of $369,000. However, only 63 percent of the variation in funding among claimants is explained by the personnel variable, and the standard-error-of-estimate (S.E.E.), a summary measure of within-sample prediction error, is very large relative to the main funding value.[1] The preliminary character of these results is thus underscored.

Other Engineering Support

The subactivity group designated as Other Engineering Support (OES) is only slightly smaller than Administration. Functions within OES tend to be carried out by base public works departments and are thus highly

1. The ratio of the two is 0.638. Anything larger than 0.10 is generally considered undesirable.

facilities-related. The predictor variable chosen was aggregate CPV (current plant value) for each claimant. Regression results were:

$$\hat{E} = 2{,}390.8 + \underset{(18.12)}{6.696C}$$

$$N = 32 \qquad \bar{E} = 19{,}310$$

$$R^2 = 0.916 \qquad \bar{C} = 2{,}526$$

$$F = 328.1 \qquad S.E.E. = 7{,}218 \quad ,$$

where

E = annual funding by claimant for the OES subactivity group, in thousands of FY 1985 dollars

C = end-of-year current plant value by claimant, O&MN-supported facilities only, in millions of FY 1985 dollars.

These results are considerably better than the preceding ones. The overall relationship is much stronger, with more than 90 percent of the variation in claimant funding being explained by CPV. The regression coefficient suggests that a change of $1 million in CPV is associated with a change in OES of $6.7 thousand. The S.E.E. value, however, is still undesirably high, perhaps suggesting that improvements are still possible in the way the regression equation is specified.

Bachelor Housing

The total number of military personnel within each claimant is the logical predictor variable for funding of bachelor housing. Regression results were:

$$\hat{B} = 17.10 + \underset{(9.19)}{0.078M}$$

$$N = 22 \qquad \bar{B} = 3{,}729$$

$$R^2 = 0.808 \qquad \bar{M} = 45{,}820$$

$$F = 84.4 \qquad S.E.E. = 2{,}544 \quad ,$$

where

B = annual funding by claimant for the Bachelor Housing subactivity group, in thousands of FY 1985 dollars

M = military personnel end-strength, officers plus enlistees, by claimant.

The regression coefficient on M, which suggests that per capita bachelor housing costs are in the order of $78 per year, must be interpreted with caution. That variable, total number of military personnel, is actually serving as a proxy for the much smaller (but unknown) number of people in each claimant who receive housing services. The fact that the value of R^2 is no higher than it is and that the S.E.E. is as large as it is relative to the mean value of B, suggests there might be considerable variability among claimants in the fraction of personnel being housed. Those results may also signal the need for certain other refinements in the regression specification.

Conclusion

Unlike the search for OBOS performance measures, the prospects of meaningful statistical analysis of the determinants of OBOS funding requirements appear to be good. Data for FY 1986 will soon be available and will greatly enhance further efforts along these lines. The data alone, however, will not be sufficient to ensure the levels of validity and reliability needed to use these tools to influence programming and budgeting decisions. The results presented above suggest the need for additions or refinements to the variables included in the regressions, as well as the possible need for alternative modeling techniques. Concurrent work in the development of a model for forecasting maintenance and repair backlog, which likewise involves pooling cross-section and time-series data for major claimants, may well lay the groundwork for such improvements.

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