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THESIS

THE IMPACT OF PERSONNEL CHANGES ON NAVY BASE OPERATIONS AND MAINTENANCE (O&M) EXPENDITURES: A MACRO AND MICRO STUDY

by

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June, 1994

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During the FY 1994 Senate Appropriations Sub-Committee meetings the Navy Operations and Maintenance (O&M) budget was reduced by $51.1 million (.25 percent). Most of the reduction was to Base Operating Support O&M. This reduction was a direct result of the budget being submitted which contained a manning level of 15,000 more personnel (2.5 percent) than the actual level authorized for FY 94. In order to better understand whether the budget reduction is appropriate, this thesis examines whether there are acceptable methods of relating base O&M expenditures to personnel levels and other variables. The question is examined at both the macro-level for the Navy and at the micro-level for San Diego Naval Station. A cost estimating model, Quick Cost, is utilized to determine the macro-level relationship. Navy and Air Force cost prediction models are introduced and compared for their usefulness at the micro-level. A regression analysis of San Diego Naval Station's O&M is shown to be misleading as O&M is negatively related to both personnel level and number of ships supported. These results are critiqued, and problems with this regression analysis are discussed. The analysis is used to develop some suggested methods of allocating manning data and other variables to Base Operating Support O&M. Further analysis of this allocation question is required.

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The Impact of Personnel Changes on Navy Base Operations and Maintenance (O&M) Expenditures: A Macro and Micro Study

by

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During the FY 1994 Senate Appropriations Sub-Committee meetings the Navy Operations and Maintenance (O&M) budget was reduced by $51.1 million (.25 percent). Most of the reduction was to Base Operating Support O&M. This reduction was a direct result of the budget being submitted which contained a manning level of 15,000 more personnel (2.5 percent) than the actual level authorized for FY 94. In order to better understand whether the budget reduction is appropriate, this thesis examines whether there are acceptable methods of relating base O&M expenditures to personnel levels and other variables. The question is examined at both the macro-level for the Navy and at the micro-level for San Diego Naval Station. A cost estimating model, Quick Cost, is utilized to determine the macro-level relationship. Navy and Air Force cost prediction models are introduced and compared for their usefulness at the micro-level. A regression analysis of San Diego Naval Station's O&M is shown to be misleading as O&M is negatively related to both personnel level and number of ships supported. These results are critiqued, and problems with this regression analysis are discussed. The analysis is used to develop some suggested methods of allocating manning data and other variables to Base Operating Support O&M. Further analysis of this allocation question is required.

TABLE OF CONTENTS

CHAPTER I. INTRODUCTION

A. AREA OF RESEARCH

This thesis is conducted to study the effect of personnel level changes on Operations and Maintenance (O&M) expenditures at San Diego Naval Station, San Diego, California. The Operations and Maintenance expenditure is a subset of Operating and Support. The following categories, which are designated Sub Activity Groups (SAG's), are examples of where the O&M funds are utilized at San Diego. Most are applicable to other similar naval facilities. [Ref 1]

- Real Property Maintenance
- Operation of Utilities
- Other Engineering Support (Includes Household Goods Moves)
- Administration
- Retail Supply Operations (Purchasing)
- Maintenance of Installation Equipment
- Bachelor Housing Operations and Furnishings
- Other Personnel Support
- Morale, Welfare, Recreation
- Base Communications
- Base Operations (ADP)
- Other Base Services (Waterfront Operations, Service Craft, Transportation)

- Hazardous Waste
- Physical Security
- Human Goals (Family Service Center)
- Other Audio Visual Support
- Environmental
- Child Care
- Federal Employee Compensation Act (FECA)

The SAG expenses are broken down in more detail by assigning expense elements to show where the money is actually being used. Some examples of expense elements are Civilian Personnel, Travel of Personnel, Supplies, Utilities and Rents, etc. The actual cost breakdown will be covered in more detail later in the study. Since the naval station does not incur the costs of its military personnel, O&M funding is the major source of funds for the base and is the more appropriate focus for this thesis.

B. RESEARCH QUESTIONS

The primary question is what is the appropriate reduction to the base Operations and Maintenance appropriation following a planned personnel reduction in the Department of the Navy? Additionally, is the amount of the reduction applied at the Department of the Navy level consistent with the reduction necessary at the naval station level?

The question of what actually drives the O&M expenditures will be raised. Whether it is personnel level or some other cost driver such as number of ships in port is an important aspect of the study. A combination of factors may be the actual case. Determining a reliable cost model can help predict future O&M needs in a changing environment.

C. DISCUSSION

There is currently no acceptable method of estimating the amount of O&M funds needed for naval bases, both on a force-wide level and on an individual base basis. If a relationship can be developed to help predict these costs, comptrollers and budget officials can better estimate and allocate funds. The more realistically that funds are initially appropriated, the better usage is made of the money as a whole.

An actual example of how the O&M "Tail" impacts the Navy's budget occurred during FY 94 hearings in the Senate Appropriations Sub-Committee. The Navy budget was submitted to reflect an end strength of personnel 15,000 greater than the actual manning level existing in the Navy. Because the personnel budget did not reflect the authorized manning level and was linked to the submitted O&M, the Sub-Committee also reduced the Navy's O&M budget by $51.1 million. This was approximately a .25 percent O&M cut due to a personnel reduction of 2.9 percent. Although this was assigned to the

O&M budget as a whole, most of the impact was to Base Support. [Ref 2:p. 51]

D. SCOPE OF THE THESIS

This study will attempt to find a relationship between personnel levels and O&M expenditures experienced at the San Diego Naval Station. This is a typical navy base that performs many functions in support of the ships and tenant commands in residence. The fact that it is such a large base may make it difficult to establish a simple relationship to explain O&M costs. With so many variables, it will be necessary to limit the scope to studying the effects on O&M expenditures due to personnel level and number of ships supported by the base. These figures are readily available and can be applied more generally to a model than such other variables as whether ships are steaming or not, ship sizes, crew compliments, and number of tenant commands just to name a few.

Granted, these factors will impact the base costs in one way or another, but for this study limiting the scope to just personnel and number of ships supported will allow relationships to be determined if they do exist. Future studies can concentrate on the other factors, incorporating them with the results obtained here.

E. METHODOLOGY

First, a macro-level model will be used to estimate the impact on force-wide base O&M costs due to a change in force structure. A discussion of the model will show how the calculations are determined. Several different changes will be developed to establish a trend.

Next, the feasibility of using an existing data base held by the Navy will be discussed. The Visibility and Management of Operating and Support Costs - Ships (VAMOSC) data base is an information system that could be used to establish some relationships in Base Operating Support costs. There are some limitations however, and these will be mentioned.

Next, data gathered from the San Diego Naval Station will be analyzed to determine how closely it resembles the model outputs. The cost data will be related to personnel levels to verify if a trend exists. As an alternative, the data will be compared to the number of ships supported in an attempt to establish a better relationship.

Using the information gathered pertaining to the various levels of prediction, recommendations can then be made to help forecast O&M costs more accurately. The applicability of the relationships brought out in the study will be discussed in hopes that a good model can eventually be constructed. Such a model could then be utilized to predict costs down to the naval station level.

F. CHAPTER OUTLINES

Chapter II discusses the Quick Cost computer model, what it is and how it makes its calculations based on an order of hierarchy. Data from the Defense Resource Model (DRM) will be used to perform the calculations. Assumptions that are made in adapting to the program will be discussed. The model will be run through several iterations to establish a trend in O&M costs based on force structure changes. Some conclusions will be added to comment on the results and what the numbers represent.

Chapter III discusses the VAMOSC data base, the information it provides and its limitations. There are significant differences between the data bases held by different services. The Air Force's data base and cost determination models will be discussed to provide an example for possible Navy cost relationships.

Chapter IV provides information about the San Diego Naval Station. The base structure will be provided, along with some background information on how costs are presently estimated. The cost data will be evaluated in a regression analysis to determine its relationship to personnel levels and also number of ships supported. These results will be compared to those from the computer model to verify if the model can be used to predict costs.

Chapter V introduces some additional models that may help in formulating cost relationships. The Cost of Base

Realignment Actions (COBRA) model and the Air Force's Base Opening Package (BOP) will be studied to utilize some of their assumptions in drawing conclusions for this study. Some options will be brought up to establish Navy cost prediction relationships such as those used in the Air Force. These could not only be used in projecting future costs but charging costs to customers that utilize the facilities.

Chapter VI will provide conclusions based upon the studies conducted. If a useable trend is established to better estimate O&M costs, recommendations can be made for further use. Additionally, recommendations can be made to improve the navy's VAMOSC data base, making it more useful in estimating support costs. Some recommendations for further research will be provided based on the findings of this study.

CHAPTER II. MACRO-LEVEL ANALYSIS

A. INTRODUCTION

A macro-level analysis of O&M funding will be conducted in this chapter using a computer model designed to assist government budget officials in their decision making. The model, Quick Cost [Ref 3], will first be described, discussing how it reaches its conclusions based upon a hierarchical structure. A section will be included discussing assumptions and limitations c.̇ using the model. Some hypothetical data will be entered into the model to determine if there is a trend in base O&M levels correlating to personnel levels. This trend, if any, will be studied later to see if it approximates that of the O&M funding of San Diego Naval Station. The chapter will end with a discussion of the results obtained.

B. MODEL DESCRIPTION

To conduct an analysis estimating the Operations and Maintenance requirements of the Naval Station a computer model tailored for service-wide estimates will be used to predict changes in costs due to changes in Navy structure. Although the model isn't predicting at such a detailed level as an individual naval station, the objective will be to see if the same changes predicted on a wide scale are applicable to those on a narrower scale. Later, actual data obtained from the naval station will be analyzed and compared to the results that the model projected. The Quick Cost computer program uses actual historical information for fiscal year 1989 and bases its predictions on the support relationships at the time. It groups cost categories into aggregated elements (AE's) since the specific cost breakdowns by program elements are classified. [Ref 4:p. 20]

The Primary AE's of Quick Cost are made up of individual ships and aircraft that make up the force structure. The Primary AE's are linked to specified Related AE's that help make up the command and control structure of the individual units. Linked to the Primary and Related AE's are the Support AE's which includes the remaining logistics, training, and general support required to sustain the given forces.[Ibid]

The AE's are grouped together in Aggregate Element Categories (AEC's). The categories that are of concern for this analysis are Central Support, Base Operating Support (BOS)-Support; and Mission Support, BOS-Combat. Within these AEC's, the Operations and Maintenance (O&M) costs are broken out, as well as other items of concern, such as personnel manning and personnel costs [Ibid:p. 21]. Other items are listed, but these three are the items that will be used in comparing the results to the actual naval station data.

The relationship between the change in force structure and the effect on the Primary, Related, and Support AE's is set into the model according to the historical link associated among the groups based on DOD experience. Each AEC is affected by the amount corresponding to its fixed/variable relationship [Ibid]. These can be adjusted to tailor the model more to specific areas of interest. If this model shows a trend close to that evidenced in the real world, small adjustments could be made to the fixed/variable ratios to fine tune the model. This could be a way to estimate future O&M costs following changes in personnel level.

The way the changes in AE's affect other AEC groups is based upon a hierarchy table which is also shown in Appendix A. For this study, since the only costs of interest pertain to base support costs, the AEC's of BOS-Combat and BOS-Support will be discussed. Both AEC's are affected by the proportional changes in Military Pay and Total O&M of the AEC's above them in the hierarchy [Ibid]. For example, the AEC's above BOS-Combat are Primary, Related, Auxiliary, Mission Support Forces (MSF): Force Training, and Management Headquarters - Combat. The percentage differences in total for Military Pay and Total O&M among the higher priority AEC's will affect BOS-Combat by that amount multiplied by the fixed/variable ratio.

The same procedure applies to calculating the changes for BOS-Support. In addition to the above AEC's, including BOS-Combat (an MSF), the Central Support Facilities (CSF's) of

Flight Training, Central Logistics, and Individual Training are included in the calculation.

C. ASSUMPTIONS

The model has no direct means to input an initial reduction in personnel. Since the main question of this study is related to a Navy-wide personnel reduction this input had to be determined indirectly. The method used for this analysis is to induce a personnel reduction by changing the number of ships in the force structure. This is a realistic assumption since a Navy-wide personnel reduction would most likely accompany the removal of ships from active duty. Table 1 shows the initial force levels and the changes associated with percentage differentials. Each force reduction (A through H) is a rounded 2.5% increment based on ship type. Because of this rounding off to the nearest whole number there are instances where a particular ship type may not be changed. This does not impact the study since this structure change is only being employed to estimate the personnel reduction at the base level.

Any numbers could have been used for this purpose, including those randomly generated. This systematic approach was taken to show equal cuts across the ship types as much as possible. Note that aircraft carriers are not included. Since they are not supported by the San Diego naval station when in port, they were not included in the force reduction implemented to induce a change in personnel. Also, Battleships (BB's), although inactive now, are included since they were active in 1989, which the cost figures of the model reflect.

TABLE 1: VARIOUS DEGREES OF FORCE STRUCTURE REDUCTION

	Initial	A	B	C	D	E	F	G	H
CG	18	0	1	1	2	2	3	3	4
CGN	9	0	0	1	1	1	1	2	2
DD	31	1	2	2	3	4	5	5	6
DDG	37	1	2	3	4	5	6	6	7
FF	41	1	2	3	4	5	6	7	8
FF(R)	8	0	0	1	1	1	1	1	2
FFG	35	1	2	3	4	4	5	6	7
AD	9	0	0	1	1	1	1	2	2
BB	4	0	0	0	0	1	1	1	1
CG-47	13	0	1	1	1	2	2	2	3
FFG(R)	16	0	1	1	2	2	2	3	3
AMPHIBS	63	2	3	5	6	8	9	11	13
AMPHIBS(R)	2	0	0	0	0	0	0	0	0
OILERS	59	1	3	4	6	7	9	11	12
SUPPORT	22	1	1	2	2	3	3	4	4

D. RESULTS

With the given inputs, the model was run to determine what the changes in base personnel would be associated with the change in force level of ships. The Operation and Maintenance requirements for base support were also determined at each level of analysis. The data of interest is summarized in Table 2.

TABLE 2: RESULTS OF FORCE REDUCTION ON BASE OPERATING SUPPORT

	BOS-Combat Percentage Changes			BOS-Support Percentage Changes		
Changes in Force Level	Manning	O&M	Personnel Costs	Manning	O&M	Personnel Costs
A	.24%	.24%	.24%	.18%	.16%	.19%
B	.59%	.59%	.59%	.44%	.44%	.44%
C	.96%	.96%	.96%	.73%	.73%	.73%
D	1.26%	1.26%	1.26%	.96%	.96%	.96%
E	1.65%	1.65%	1.65%	1.25%	1.25%	1.25%
F	1.93%	1.93%	1.93%	1.46%	1.46%	1.46%
G	2.26%	2.26%	2.26%	1.72%	1.72%	1.72%
H	2.65%	2.64%	2.64%	2.01%	2.01%	2.01%

With these figures, an estimate provided by the model could possibly determine a relationship between changes in personnel level and base operating costs. The lower figures for BOS-Support are attributed to its placement below BOS-Combat in the hierarchy table. Table 3 shows the total percentage changes in personnel and corresponding changes in operating costs for base support. This combines BOS-Combat and BOS-Support.

The resulting numbers correspond nearly identically between percentage changes in personnel and changes in base O&M costs. The low percentage change compared to the percentage change in ships is due to BOS AECs' being based partially on personnel costs and O&M cost changes of the upper hierarchy AEC's. The results show that the O&M percentage changes are nearly identically linked to changes in personnel levels. No graph is necessary to show the relationship since the numbers nearly fit a one-to-one relationship in percentage changes. The linear relationship, although expected due to the specification of the computer program, is not realistic. This is especially true for larger changes, which may change costs more dramatically due to economies of scale being lost. These numbers reflect the default settings in the computer model, based upon data gathered during the Cold War years. Recently, an updated data base to the model was released based upon information gathered during cutbacks in the DOD. Future efforts in this area of study can utilize the new model data and compare the results to those obtained by this thesis.

TABLE 3: COMBINED BOS RESULTS (BOS-COMBAT AND BOS-SUPPORT)

	A	B	C	D	E	F	G	H
% Change in Personnel	.22%	.54%	.88%	1.15%	1.51%	1.76%	2.07%	2.42%
% Change in Base O&M	.21%	.53%	.87%	1.14%	1.50%	1.75%	2.05%	2.40%

CHAPTER III. THE VAMOSC DATA BASE

A. INTRODUCTION

This chapter will provide a discussion and evaluation of existing data bases used by both the Navy and Air Force. Limitations of the Navy model will be discussed, as well as a prototype study to improve the forecasting ability of the Navy data base. The Air Force model will be introduced to show how that service accounts for Base Operating Support. Additionally, the methods used for calculating Base Operating Support will be discussed in an effort to apply similar measures to the Navy.

B. THE VAMOSC MODEL

One possibility a budget forecaster has to aid in predicting costs is the Visibility and Management of Operating and Support Costs (VAMOSC) - Ships [Ref 5]. Ic is a data base that breaks down the year's Operating and Support costs for Navy ships that were active during the applicable fiscal year. The senior representative for the data base is the Office of the Assistant Secretary of the Navy (Financial Management). Its resource sponsor is the Chief of Naval Operations (OP-431). It is managed by Commander, Naval Sea Systems Command with the Program Manager being NAVSEA 01753. [Ibid:p. 1]

Data tables are provided, broken down by individual ship and ship type. The major categories covered by VAMOSC are [Ibid:pp. 7-20]:

- Direct Unit Costs: Costs incurred by the ship to support and maintain its own operations.
- Direct Intermediate Maintenance: Costs of maintenance to the ship by Navy operated and supported ship maintenance facility.
- Direct Depot Maintenance:Costs of maintenance to ship by a shipyard facility; not Navy supported.
- Indirect Operations and Support: Costs not chargeable to fleet units but support ships operations. Sub-categories covered are:
  - -Training
  - -Publications
  - -Engineering and Technical Service
  - -Ammunition Handling

These categories are included in the Quick Cost model among many other categories. The Direct Unit Costs are found with the primary cost data under O&M for each platform. The remaining VAMOSC categories are covered under the support function areas of Quick Cost. Direct Intermediate Maintenance, Direct Depot Maintenance, Publications, Engineering and Technical Service and Ammunition Handling are all included as a part of the Logistics Aggregated Element (AE). Training has its own AE in the support area. It is evident that Quick Cost provides more categories of detailed information than the VAMOSC database does, though at a more aggregated level.

C. LIMITATIONS OF VAMOSC

An examination of the categories and sub-categories covered by VAMOSC shows that there is no mention of Base Operating Support costs used to support the ships. There are some maintenance categories that are provided but it will be shown in the next chapter that these costs are not borne by Naval Station, San Diego. The category of Indirect Operations and Support includes costs that do not result in an expense against fleet O&M [Ibid:p. A-115]. In order to make effective use of the VAMOSC data in the format that now exists, Base Operating Support (BOS) costs need to be included in that category. Another major limitation is the fact that there is no VAMOSC data that directly provides Operations and Support cost data for supporting bases. The data is only tabulated according to fleet units. One final shortfall of using the VAMOSC tables is that since the data is a collection of historical information based on ship type, there is no information available as new ship classes enter the fleet. This makes it extremely difficult to associate costs for newly commissioned vessels or make projections several years in advance when even newer ships are planned for construction. The best that can be done in these cases is to develop an estimate, using data from similar ship types until enough factual cost information is gathered for the platform.

If BOS data were included in the Indirect Operations and Support category, a procedure similar to that used with the

Quick Cost model of the previous chapter could be taken. A force reduction in personnel would have to be related to a particular number and type of ships that would be taken out of service. In order to make use of the VAMOSC data and apply it to bases the user will have to determine what percentage of the base O&M is driven by support of ships. Once that estimate is determined, using the VAMOSC tables, data for the ships home ported at the base can be totalled. Using the estimated ratio of Base Support to Ships to Total Base O&M, an estimate for Base O&M can be determined. This is an indirect method that as of yet cannot be accomplished until the Base Operating Support costs are included in VAMOSC.

Some steps have been taken to help account for base operating support costs for ships. A preliminary study of BOS, correlating those costs to ship types, is currently being conducted by the Naval Center for Cost Analysis. The elements of BOS considered are Home Port BOS, Commissaries and Exchanges, Family Housing, and Command Staffs. [Ref 6:p. 2]

The methodology used in the study attempts to allocate home port BOS cost by first identifying costs that are related to ships, and second, allocating the costs to individual ships. The allocation method used is number of man-days in port, both by ship and shore based personnel. There is a problem identified in this method. Although it succeeds in allocating the costs to individual ships, there is still no adequate method for validating the allocation procedure. An example is given comparing the O&M allocation of San Diego Naval Station and Alameda Naval Air Station using this method. With the O&M expenditures of both bases nearly the same, the rate per man day for Alameda is nearly three times the amount of San Diego. This is because San Diego operates with more ships and accumulates more man days in port with which to distribute the costs. If the O&M associated with ship support could be more fairly broken out the man day rates would be more similar. [Ibid:p. 5]

Although the VAMOSC BOS study is not complete, preliminary recommendations indicate that Commissaries and Exchanges and Family Housing should be deleted as a BOS cost element. The reason for this is that the facilities are meant to serve personnel, not ships. The costs of operating these facilities should not be proportionally divided among ships. It should be noted however, that increasing the number of ships will increase the number of personnel using the base and therefore the use of installed facilities. The study also recommends not allocating O&M costs of Command Staffs to ships since none of these linkages could be identified. This leaves Home Port BOS as the only category remaining. There are current difficulties in obtaining this figure since the ship-related costs are not identified. Some recommended options are to have future reports include these costs separately or utilize a ratio that can be applied to the total base O&M. Detailed evaluation of base expenditures could be done to determine the relationships according to spending category. [Ibid:pp. 8-14]

Since this VAMOSC BOS study is still ongoing, more categories could be added and some of these could be taken out. The study, however, is an important step toward incorporating BOS costs in the VAMOSC data base. While VAMOSC cannot currently be used to estimate the relationship between personnel levels and base operating costs, with the future incorporation of BOS data, such relationships will be available.

D. THE AIR FORCE EXAMPLE

The United States Air Force has created a relationship of personnel and square footage to base operating costs.

> The Cost-Oriented Resource Estimating (CORE) Model is designed to provide a cost-estimating model that may be used to develop aircraft squadron annual operating and support (O&S) cost estimates. [Ref 7:p. 111]

The category of this model that includes base operating support is called Installation Support Non-pay. A combination of authorized military strength and square footage leads to the following algorithms:

For CONUS (Continental US):

(authorized military)($1819 per military)+(authorized military)(1235 square feet per military)($2.60 per square foot).

For non-CONUS:

(authorized military)($2782 per military)+(authorized military)(1235 square feet per military)($2.80 per square foot). [Ibid:p. 113]

The authorized military terms can be factored out of the equation to leave the following:

For CONUS:

(authorized military)[1456+(1235)(2.60)]

For non-CONUS:

(authorized military)[2782+(1235)(2.80)]

The Air Force has a composite equation that doesn't separate out CONUS and non-CONUS. It is:

(authorized military)[1819+(1235)(2.60)]

Once calculated, this figure can be used as an input to determine the amount of annual base operating support required for a given aircraft squadron. The composite equation would reduce to:

$5030 * (authorized military)

The authorized military term is the sum of the following [Ibid:p. 120]:

- PPE Officers (Crew, Maintenance, Wing/Base Staff, Weapon Security)
- PPE Enlisted
- BOS Officers (Base Operating Support)
- BOS Enlisted
- RPM Officers (Real Property Maintenance)
- RPM Enlisted

- MED Officers (Medical)
- MED Enlisted

With no intercept term in the equation above, this relationship appears to account only for variable costs. It will be shown in Chapter V that once the fixed cost of the base is estimated, further adjustments to O&M will be made using variable cost relationships such as the CORE model.

Besides the CORE model, the Air Force also has its own VAMOSC to help relate support costs to its weapon systems. Volume II, which includes the Weapon Systems Support Costs (WSSC) breaks O&S costs down into the following categories [Ref 8:p. 4]:

- Unit Mission Personnel
- Unit Level Consumption
- Depot Maintenance
- Sustaining Investments
- Installation Support
- Medical
- PCS
- General Depot Support
- Second Destination Transportation
- Personnel Acquisition and Training

The Type 2 Interrogation report provides a cost breakdown that includes the installation support for a Mission Design

Series (MDS) aircraft during a particular fiscal year. The installation support is broken down into categories of real property maintenance, communications, and base operations. [Ibid:p. 21]

The method of allocating the base operating costs to aircraft support for the WSSC is performed with personnel strength ratios. The ratio is calculated by taking the number of base personnel providing O&M support to a squadron and dividing by the base's total number of personnel. Air traffic control costs (in total), plus the remaining O&M costs multiplied by the strength ratio, give the base's O&M attributable to aircraft. The total is further divided based upon flying hours and number of hours the base has responsibility of the aircraft (possessed hours). This will give operating squadrons a higher percentage of the base O&M costs. "It is assumed that installation support costs are proportionate to assigned O&M strengths and to flying hours and possessed hours." [Ibid:pp. 39-40]

E. CONCLUSIONS

Since the Navy has not yet found a workable relationship to allocate base operating support, VAMOSC is not a useable tool for determining the question in study. If a relationship can be found similar to that used by the Air Force, which relates base costs to ships, then a prediction model could be constructed using some starting assumptions. As in the Quick

Cost model, a force-wide reduction in personnel would have to be input using a decrease in a number of ships accompanying the reduction. From that, based on the number of ships supported by the base, an estimate of the change in O&M for ships could be determined. A baseline ratio of the bases ship O&M to its total would then allow calculation of the total base O&M resulting from the change.

A direct calculation of the base O&M variable costs, such as that used in the Air Force CORE model, might also be a possibility. The relationship may not be as easily determined, using square footage and personnel as is the case for the Air Force. Some other inputs, such as pier space or ships' in port days could be factors to consider. These considerations will be looked at in closer detail later in the study, following the next chapter's analysis of the Naval Station data.

CHAPTER IV. NAVAL STATION REGRESSION ANALYSIS

A. INTRODUCTION

The micro-level analysis will be presented in this chapter with a case study of San Diego Naval Station's O&M expenses. First some background information will be provided, including the pertinent data for study. Regression analysis of O&M expenses will be employed with a variety of independent variables. Since the purpose of this study is to determine the relationship between personnel and O&M expenses, that will be the first area of investigation. Next, there will be a supplemental regression using the number of ships in port as an explanatory variable. Finally, a multiple regression will be conducted with the two independent variables to determine if a usable prediction model can be formulated. The chapter will end with some conclusions of this micro analysis.

B. BACKGROUND INFORMATION

San Diego Naval Station is the largest home port on the west coast for navy ships. As such, it incurs a wide range of costs associated with the many functions performed supporting the ships and tenant commands located on the base.

The O&M data and information concerning the base operations was gathered directly from naval station records obtained from the Base Comptroller's office. The Budget

Officer provided supplemental information concerning the base operations and expenditures. [Ref 1]

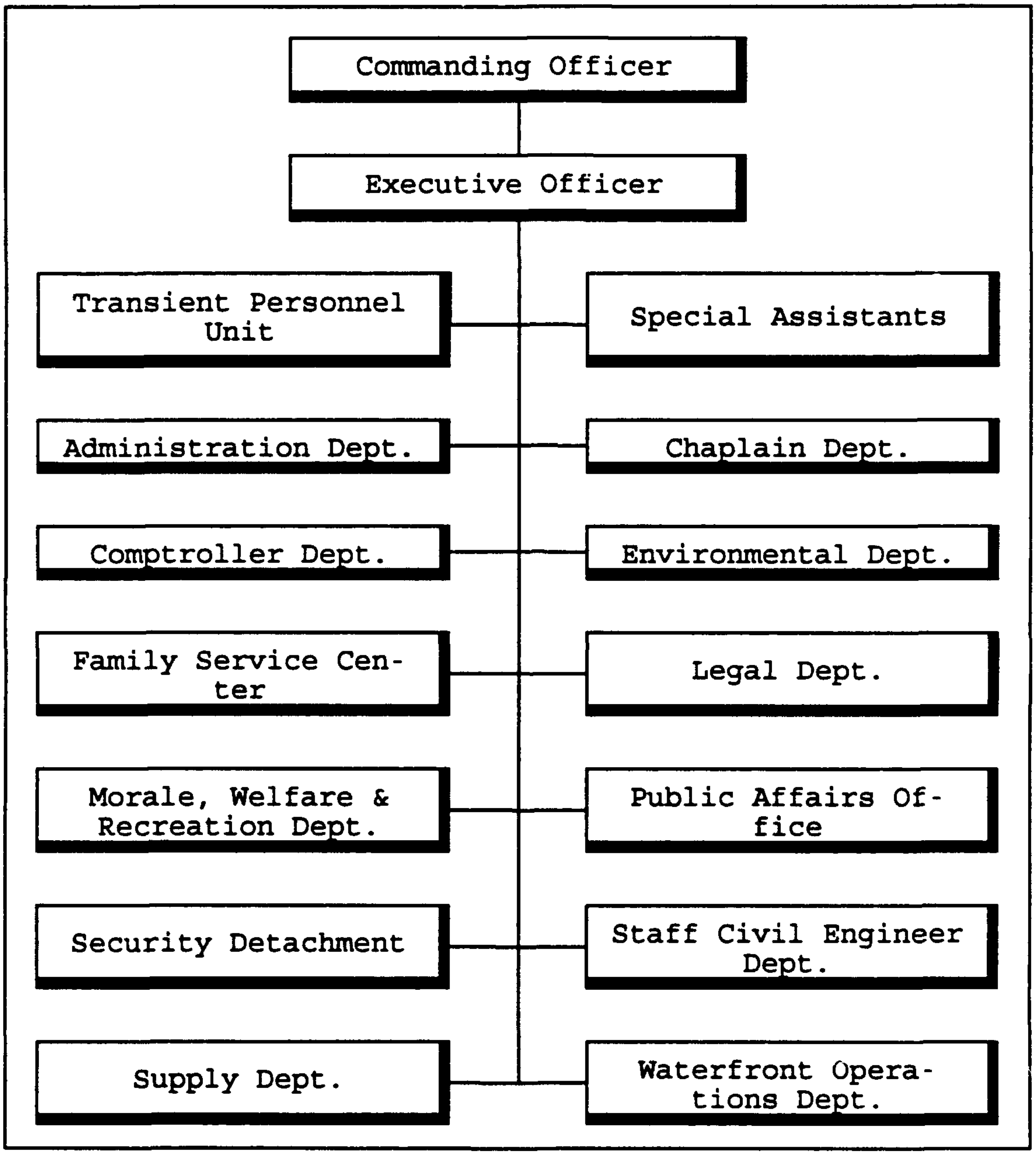

FIGURE 1: SAN DIEGO NAVAL STATION ORGANIZATIONAL STRUCTURE

1. Naval Station Organization

Figure 1 shows the organizational structure for San Diego Naval Station. It is evident that some obvious activities are missing such as medical facilities, Navy exchange and commissary, Intermediate Maintenance Activity (IMA) and Supply facilities. Although these organizations do exist at the naval station, they are considered tenant commands and receive their own O&M funding. Since the purpose of this study is to determine if personnel levels have an impact on the naval station's O&M, the expenditures of the tenant commands will not be considered. The presence of the commands, however, will impact the Naval Station's own O&M funds and that is relevant to this study.

2. Naval Station O&M Data

O&M data was gathered from financial records for fiscal years 1985-93. Table 4 shows the authorizations for each of the fiscal years. The Consumer Price Index (CPI) is also included to convert the dollar amounts to a constant dollar. The CPI indexes are based on the 1982-84 value as the base year.

The manning figures are provided in Table 5. These numbers were gathered from manning documents for each of the years given. No documents were available for FY 85. It should be noted that even though the documents state a particular manning level, the actual manning fluctuated around that number throughout the year. This "average" number that is provided will be sufficient to conduct the study.

TABLE 4: SAN DIEGO NAVAL STATION O&M AUTHORIZATIONS

FY	FINAL AUTH ($K)	CPI[1]	CONSTANT $ ($K)
1985	30,881	1.076	28,700
1986	28,216	1.096	25,745
1987	31,298	1.136	27,551
1988	30,197	1.183	25,526
1989	33,823	1.240	27,277
1990	34,424	1.307	26,338
1991	40,272	1.362	29,568
1992	42,305	1.419[2]	29,813
1993	42,568	1.458[3]	29,196

TABLE 5: SAN DIEGO NAVAL STATION MANNING LEVELS

FY	OFFICERS	ENLISTED	CIVILIAN	TOTAL
1986	31	593	308	932
1987	30	590	300	920
1988	30	589	300	919
1989	29	589	296	914
1990	30	589	396	1015
1991	31	515	296	842
1992	32	515	308	855
1993	34	520	344	898

[1] [Ref 9:p. 469]

[2] [Ref 10:p. 33]

[3] [Ref 11:p. 15]

Figure 2 shows the graphical relationship between authorized O&M funds and personnel levels during fiscal years 1986 through 1993.

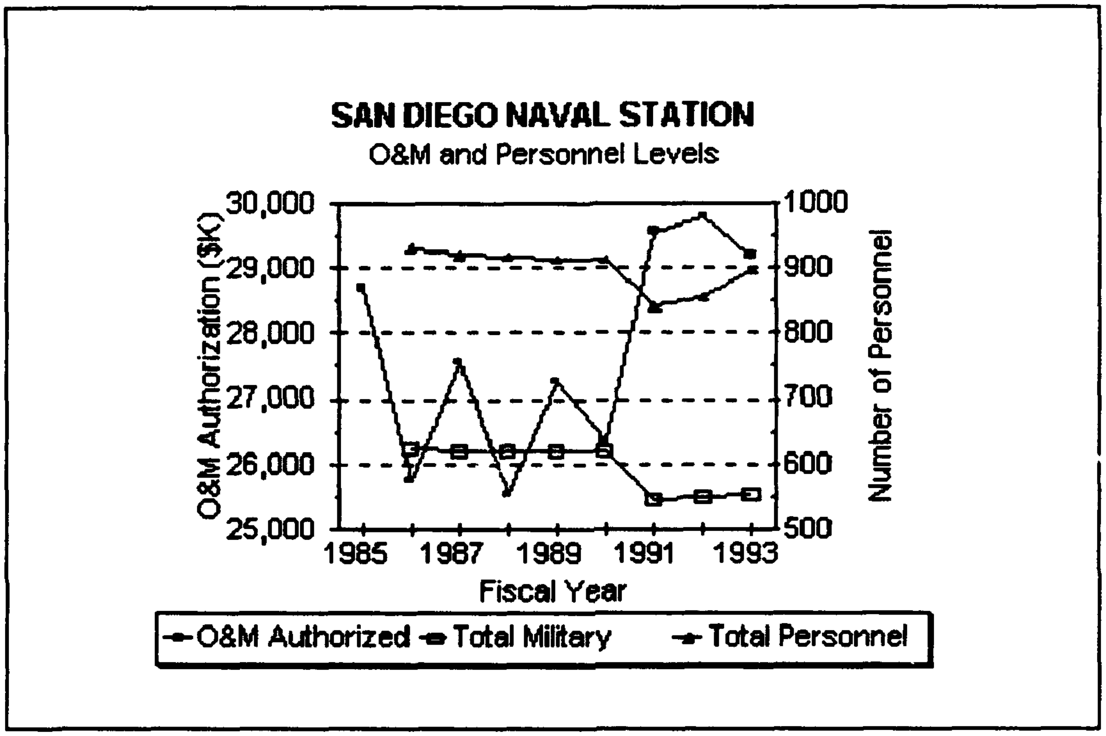

FIGURE 2: SAN DIEGO NAVAL STATION O&M AND PERSONNEL LEVELS

C. REGRESSION ANALYSIS

The computer program used to perform the regression analysis is the Student Version of Minitab, v 8.0. Each regression will be performed, followed by a critique of how well the model works and if the required assumptions are met. These assumptions include the dependent variable, O&M dollars, being linearly related to the independent variables; the error variance should remain constant over the range of values; and the error terms should not be related to one another [Ref 12:pp. 21-24].

1. O&M Expenses vs Personnel

Two regressions will be conducted relating to personnel. The first one will be the O&M funding versus total personnel. The second will be O&M versus total military personnel. The reason for the second regression is that the basis that Congress reduced Navy O&M for FY 94 was military end strength. An analysis using total personnel also needs to be accomplished since there is such a large percentage of civilian workers at the naval station.

Table 6 shows the results of the regression of O&M versus total personnel. The calculated equation is:

$$Y=67.9-.0448X$$

Y is the predicted O&M funding level (constant $) and X is the total personnel level.

TABLE 6: REGRESSION OF O&M VS TOTAL PERSONNEL

Predictor	Coefficient	Std Dev	t-ratio	p
Constant	67.888	9.919	6.84	.000
Personnel	-.04477	.01102	-4.06	.007

R-squared: 73.3%
F value: 16.49
Durbin-Watson statistic: 2.06

These are fairly good results. The t-ratios and F value indicate a good relationship between O&M and total personnel. The R-squared value means that 73.3% of the O&M

variation from its mean is explainable by the independent variable. The Durbin-Watson statistic being nearly 2.0 shows that there is virtually no autocorrelation between the error terms. One item that is surprising is the negative relationship between total personnel and O&M funding. This appears contrary to the imposed reduction based on decreased personnel.

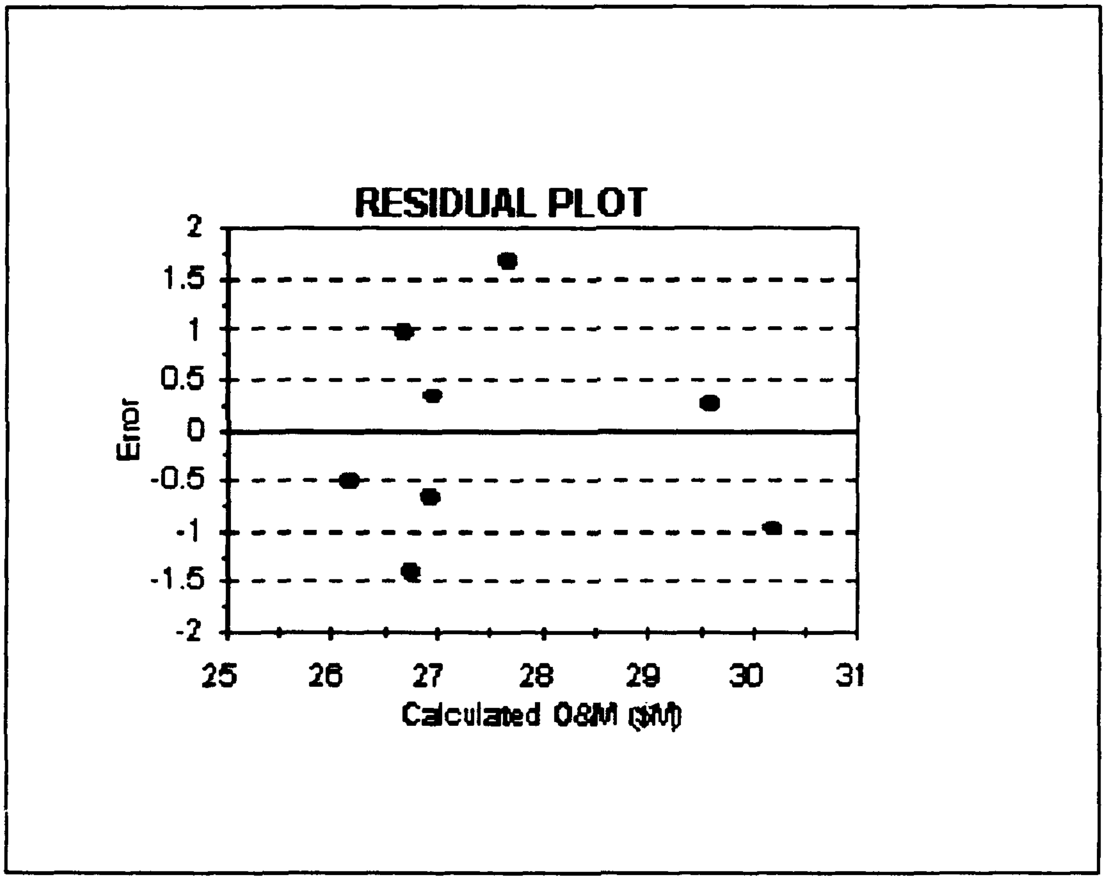

FIGURE 3: RESIDUAL PLOT OF O&M VS TOTAL PERSONNEL

Figure 3 shows the residual analysis plot of the error terms versus the calculated value of O&M. There is no distinctive pattern to the plot. The error, with this small sample size appears to remain consistently within plus or minus \$ 1.5 million of the calculated O&M values. The fact that there is no distinctive curvature to the plot also indicates that the relationship is approximately linear. This model therefore meets all of the regression assumptions.

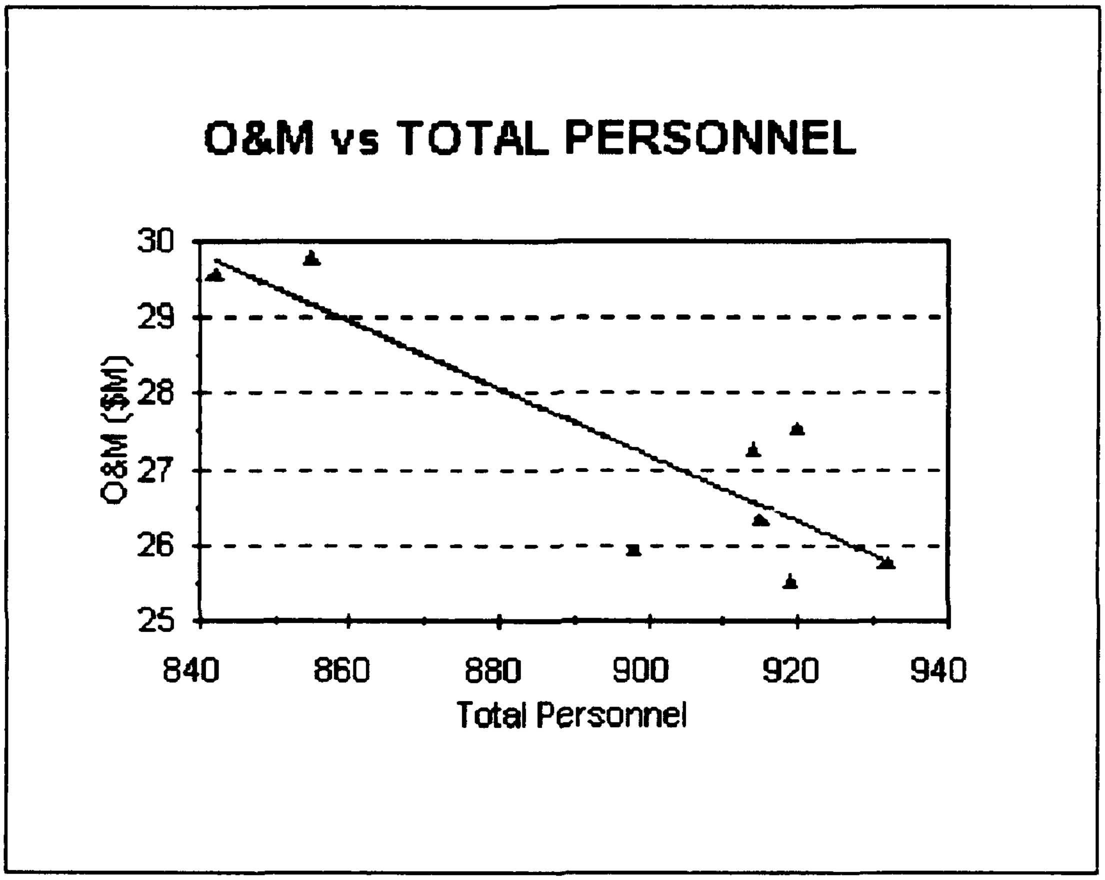

FIGURE 4:REGRESSION OF O&M VS TOTAL PERSONNEL

Figure 4 shows the resultant plot with the regression line superimposed over the raw data. Obviously there are not enough data points to get an accurate plot, but with the information utilized, the plot looks reasonable.

Now, proceeding with the study, the next step will be analyzing O&M versus Total Military personnel. Similar to the first regression, the result shows a negative coefficient for the X variable. The resulting linear fit equation is:

$$Y = 53.2 - .0431X$$

Table 7 shows the regression results.

TABLE 7: REGRESSION RESULTS OF O&M VS MILITARY PERSONNEL

Predictor	Coefficient	Std. Dev.	t-ratio	p
Constant	53.223	4.352	12.23	.000
Military Personnel	-.043137	.007322	-5.89	.001

R-squared: 85.3%
F value: 34.71
Durbin-Watson statistic: 3.55

Although the t-ratios, R-squared and F value all appear well within limits of a good model, the Durbin-Watson statistic, being so close to its maximum value of 4.0, indicates a problem. Examining the residual plot may identify additional problems. Figure 6 shows these results.

There is a large reduction in error as the value of calculated O&M increases. This violates one of the assumptions that must be met in order to have a good model. Based on this fact, the more useable model of the two attempted so far is the one using Total Personnel to drive O&M.

2. O&M Expenses vs Number of Ships

To carry the analysis further, in an attempt to determine if there is a better predictor of O&M funding, the number of ships supported by the naval station will be analyzed. The

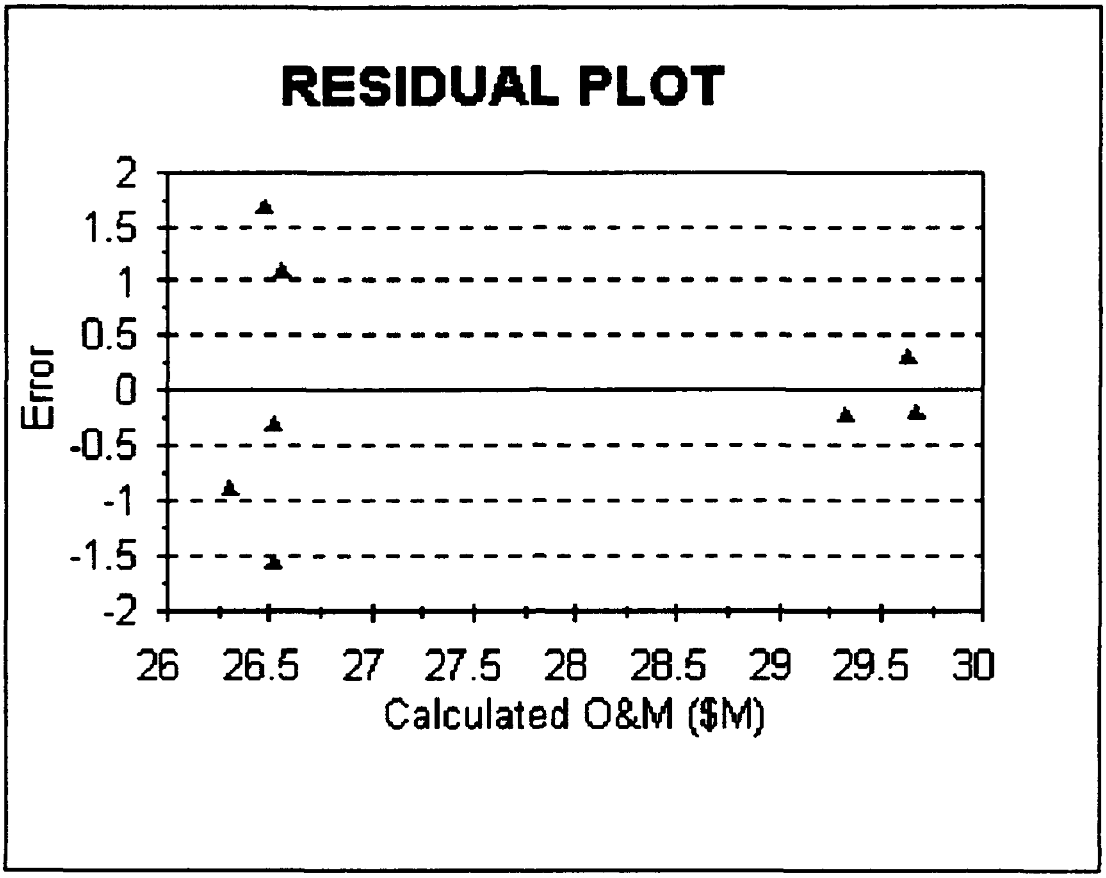

FIGURE 6:RESIDUAL PLOT OF O&M VS MILITARY PERSONNEL

TABLE 8: SHIP SUPPORT DATA

Fiscal Year	Average Ships per Day
1986	45.0
1987	44.8
1988	47.7
1989	38.5
1990	38.4
1991	39.9
1992	33.5
1993	30.8

independent variable to study in this section is average number of ships in port each day for each of the years that O&M data is available. This should be a good indication of the naval station's workload which should in turn reflect the O&M dollars utilized. Listed in Table 8 is the ship data taken from the waterfront operations office records.

The regression result provides the following linear fit equation:

$$Y = 36.3 - .219X$$

Again, this is surprising since one would expect the value of O&M to increase with the number of ships supported. The remaining regression data is summarized in Table 9.

TABLE 9: REGRESSION OF O&M VS NUMBER OF SHIPS SUPPORTED

Predictor	Coefficient	Std. Dev.	t-ratio	P
Constant	36.334	3.246	11.19	.000
Ships	-.21864	.08076	-2.71	.035

R-squared: 55.0%
F value: 7.33
Durbin-Watson statistic: 2.30

The results are not quite as good as the regression against Total Personnel. The t-ratio of -2.71 is lower than those obtained in the previous regressions for the relevant variables explaining O&M costs. There is also a smaller F value obtained, and the R-squared value is lower than the previous regressions. The Durbin-Watson statistic does look satisfactory, showing no autocorrelation among the error terms. In analyzing the residuals further, the plot is shown in Figure 7. This looks like a good dispersion of the error values. There is no significant pattern which would indicate non-linearity. Additionally, the values appear to remain consistently between -1.5 and 1.5, meeting the constant error criterion.

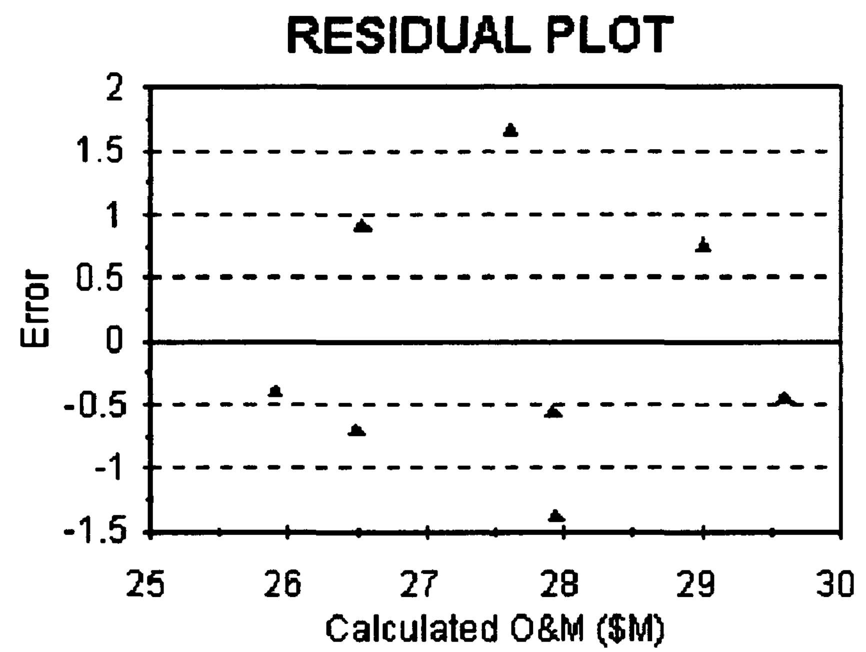

FIGURE 7: RESIDUAL PLOT OF O&M VS SHIPS SUPPORTED

Overall, although this model meets the required assumptions, it is not as good as the example using Total Personnel as the independent variable due to the lower t-ratio, F value and R squared value. It may have some role, and this will be determined in the next section where a multiple regression will be performed using Total Personnel and Number of Ships as the independent variables.

3. O&M Expenses vs Personnel and Number of Ships

After performing this multiple regression, the resulting equation is:

$$Y = 63.0 - .0338\ X1 - .123\ X2$$

With X1 being Total Personnel and X2 being Ships Supported. Note the negative coefficients remain, which is not surprising, given the results of the single variable regressions of the two terms. The regression results are summarized in Table 10.

TABLE 10: MULTIPLE REGRESSION RESULTS

Predictor	Coefficient	Std. Dev.	t-ratio	P
Constant	62.974	8.066	7.81	.001
Personnel	-.033845	.009942	-3.40	.019
Ships	-.12324	.05607	-2.20	.079

R squared: 86.4%
F value: 15.93
Durbin-Watson statistic: 2.48

The results appear good, although the t-ratios for the independent variables are at the lower limit, particularly the t-ratio for the variable of Ships Supported, which has a p-value of 7.9 percent probability of being a random parameter value. The R squared value is the best thus far and the Durbin-Watson statistic is acceptable in showing no auto correlation among the error terms. The residual plot is shown in Figure 8.

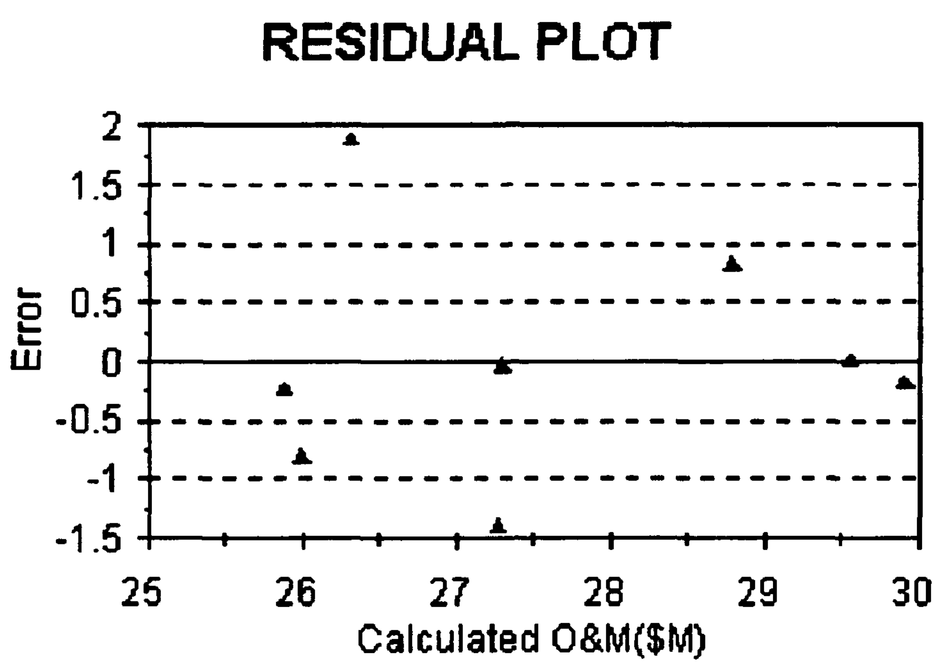

FIGURE 8: RESIDUAL PLOT OF MULTIPLE REGRESSION

The plot shows no pattern of curvature which supports the non-linearity assumption. There may be a problem with constant variance in the error terms getting smaller but it is difficult to conclude that with the small sample size. Overall, this appears to be the best model using the collected data.

These regression models, however, cannot be taken as an accurate prediction model. If these models reflected the proper trend, then Congress should have increased the O&M as the personnel levels decreased. There are factors that most likely have not been accounted for, causing the O&M values to be negatively related to number of ships supported and personnel levels. The critique of these regressions in the next section will bring out a few of these points.

D. REGRESSION ANALYSIS CRITIQUE

The regression analyses performed in this chapter demonstrated how calculations of this nature could be misleading and could not be relied upon for predicting O&M costs. This section will bring up some ideas as to why regression analysis was so inappropriate. The problems addressed are non-homogeneous expenditure data, limited data points, and a simultaneous equation problem.

1. Non-Homogeneous Data

There is concern as to why the Naval Station's O&M costs increased while personnel levels and number of ships supported decreased. This is contrary to the expected result, especially in light of Congress cutting O&M due to lower personnel levels. To investigate this further, the Naval Station's expenditures will be broken down and analyzed to determine where the O&M funding actually were utilized. This should show where the increased expenditures occurred, therefore causing the trends that exist in the regression analysis.

The expense data was gathered from financial records at the Naval Station comptroller's office. Although the total yearly figures used in the regressions were available for nine years, a detailed listing of expenses were available for only the last five years. A summarized listing of the data is shown in Appendix B. The items are adjusted to constant 1982-84 dollars and are broken down into two categories. The first major grouping is the Sub Activity Group (SAG) list. These are the expense centers that generate the O&M expenditures for the Naval Station. The other grouping lists the expenditures by Expense Element (EE). Every purchase that a SAG initiates is assigned a sub-category EE. The EE list is the more detailed listing of what the dollars were actually used for since each SAG spends its money across several elements. Both lists will be examined to determine their spending trends over the five year period.

Table 11 shows the SAG items that show either a significant increase or decrease over the five year period. Note the items with the upward trend over the five years are MRP and Minor Construction. MRP is maintenance and repair of existing facilities while Minor Construction is for new facilities. These are considered a part of O&M. As a rule, there is a limit of $25,000 per job funded from Minor Construction. If not, the money has to come from Military Construction, a separate appropriation category.

TABLE 11: NAVAL STATION SAG EXPENDITURES - CONST $K (1982-84)

SAG	1989	1990	1991	1992	1993
Maintenance and Repair of Real Property (MRP)	5741	5176	6970	7222	7243
Minor Construction	517	499	686	808	941
Other Engineering Support	2604	2531	2680	2223	3028
Other Personnel Support	2411	2503	2656	2145	1387
Other Base Services	6151	5061	5280	4707	3877
Family Service Center	0	0	0	588	740
Child Care	0	0	0	1301	1345

The SAG's showing a downward trend are Other Personnel Support and Other Base Services. Other Base Services is predominately Waterfront Operations, which is almost entirely used in support of ships in port. The other items listed are of special significance. Other Engineering Support is a SAG that includes costs of personnel household goods moves (approximately $2 million per year), not only for the Naval Station but for the entire San Diego area. The Family Service Center and Child Care SAG's were implemented in FY 1992 as special interest items to be tracked by the Naval Station's type commander [Ref 1]. The two data points available show the start of an upward trend in those categories. Figures 9 and 10 compare these SAG listings with the numbers of personnel and ships over the same time frame.

Looking at Figures 9 and 10 it is fairly easy to recognize the downward trend in Waterfront Operations spending

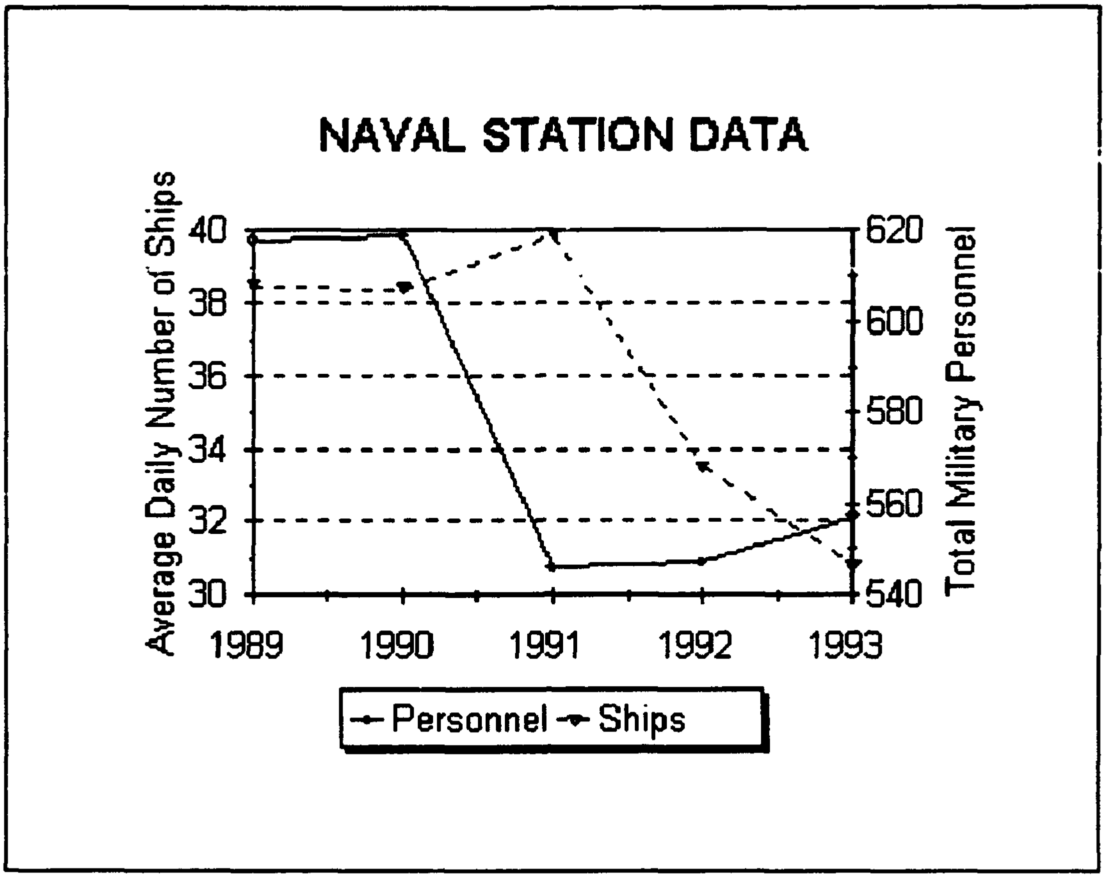

FIGURE 9:SAN DIEGO NAVAL STATION DATA

and Other Personnel Support. These resemble the patterns shown by personnel levels and ships supported. Contrary to this trend is the increased spending rates for MRP and Minor Construction. These items increase although the personnel levels and ships are decreasing. The congressional O&M reduction does not follow this type of trend and none of the models used thus far account for it.

One item that needs to be discussed is the impact of the current "downsizing" of the Navy on the San Diego Naval Station. In a discussion with the Budget Officer, it is apparent that as other commands are being closed or reduced in

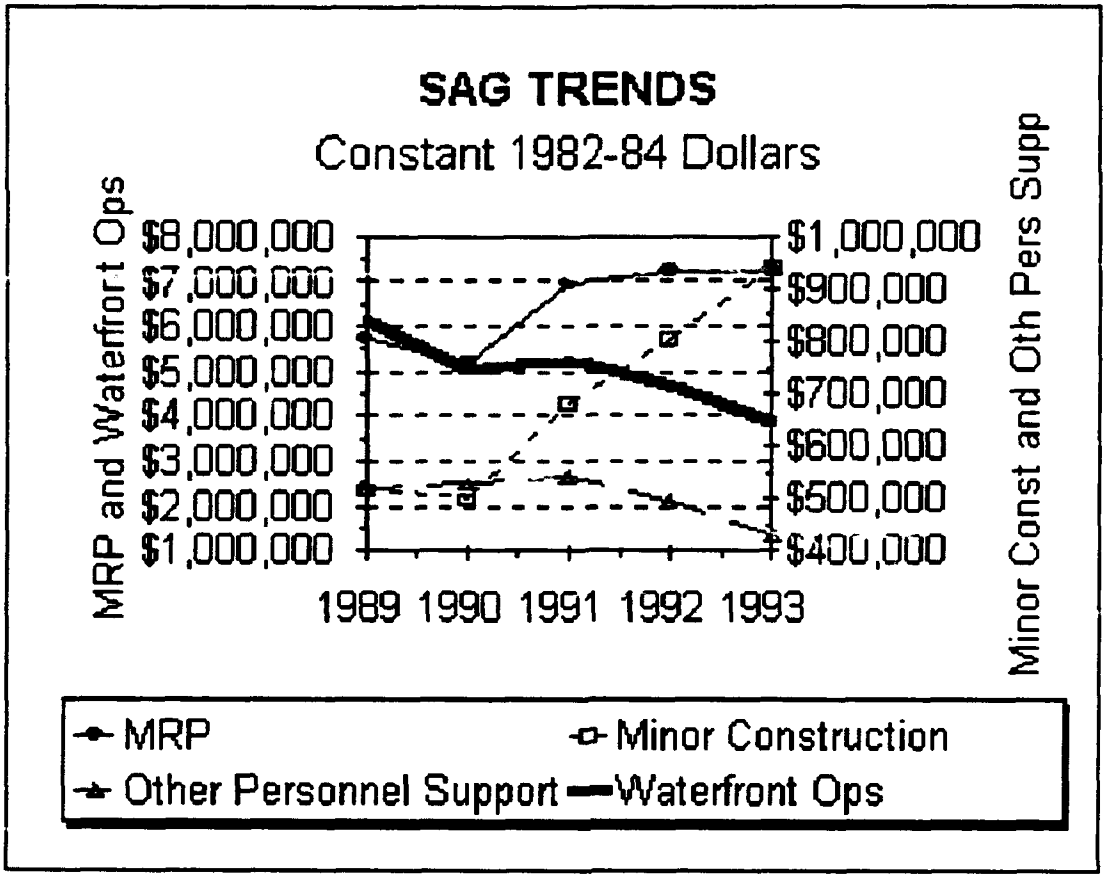

FIGURE 10: SAG SPENDING TRENDS

size, the Naval Station is assuming more responsibilities [Ref 1]. This could lead to an increased emphasis on items that go beyond the personnel assigned to the station or ships supported.

Table 12 shows significant Expense Elements that show either a decreasing or increasing trend. When plotted in Figure 11, the trends of these Expense Elements are more readily apparent. The increases are in Civilian Personnel wages and Supplies, while Public Works Center (PWC) activity has shown a small, overall decline. The rising Civilian Personnel wages corresponds closely to the increased Civilian Personnel level over the past two years. There is an increase in PWC work in FY 1991 but that trend does not appear to continue past that one year gain.

TABLE 12: NAVAL STATION EE DATA ($K)

EE	1989	1990	1991	1992	1993
PWC	14,781	14,181	17,533	14,002	13,836
Supplies	1431	1722	1743	3135	3302
Civilian Personnel	6043	6207	6536	7008	7061

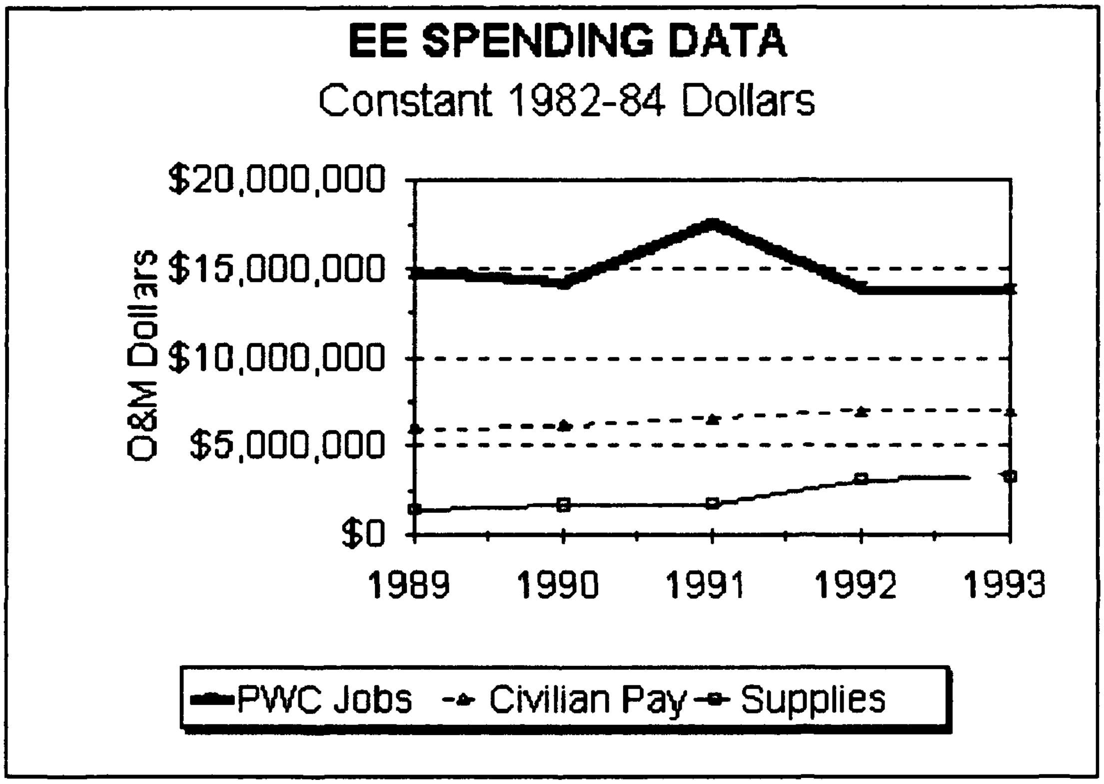

FIGURE 11: EE SPENDING DATA

What these charts indicate is shifts in emphasis and/or needs of the Naval Station over the past five years. While the O&M spending has gone down in Personnel Support and

Ship Support areas as one would expect with the draw down, increases in other areas such as Repair and Construction are dominant. This type of spending trend shift is not apparent when conducting the simple regression analysis. The lack of homogeneity of the data base of O&M expenses yields misleading results when regression analysis is employed. While one might try to conduct a regression with the five data points this chapter reflects, there are other SAG's and EE's that would go to ship or personnel support but can not be as easily distinguished. This would make it difficult to develop a dependable prediction formula. Also the limited data points would make the regression less reliable.

2. Limited Data Restriction

The eight data points available provide little information in conducting regression analysis. It would be interesting to try some lag models to determine if the independent variables have a delayed impact on the dependent variable, O&M spending. Lags in regression reduce the number of data points depending on the number of periods lagged. Additionally, if any extra independent variables are introduced, they impact the number of degrees of freedom available. The Stock Adjustment Model [Ref 13:pp. 215-216] is worth discussing but a regression analysis will not be done because it does introduce an extra variable along with one or more time lags.

Starting with the basic relationship we have:

$$O\&M_t^* = \alpha_0 + \alpha_1 MILPERS + \alpha_2 SHIPS + \epsilon_t$$

The Stock Adjustment Model assumes that the desired level of O&M is dependent on the level of the independent variables. In this case that would be Military Personnel and Ships. To determine what the relationship is between the desired level of O&M and the actual O&M used the following relationship is given:

$$O\&M_t - O\&M_{t-1} = \gamma\,(O\&M_t^* - O\&M_{t-1})$$

where $0 < \gamma < 1$ and $O\&M^*$ is desired O&M level

Substituting the basic cost relationship in for $O\&M^*$ gives the following equation:

$$O\&M_t - O\&M_{t-1} = \gamma\,(\alpha_0 + \alpha_1 MILPERS + \alpha_2 SHIPS + \epsilon_t - O\&M_{t-1})$$

Solving for the resulting O&M level gives the following equation:

$$O\&M_t = \gamma\alpha_0 + \gamma\alpha_1 MILPERS + \gamma\alpha_2 SHIPS + (1-\gamma)\,O\&M_{t-1} + \gamma\epsilon_t$$

If more data points were available it would be interesting to see how the regression of this equation would turn out. As it is, just lagging the equation one time period would reduce the observations by one and the new variable also eliminates a degree a freedom. Starting with eight data points, this would only leave three degrees of freedom. The biggest problem with so few data points is that there is not enough information to conduct advanced analysis and so little information to develop a trend.

3. Simultaneous Equation Problem

While the best regression results were obtained using Total Personnel as an independent variable instead of just Military Personnel, there is a built-in bias problem due to simultaneity of the Total Personnel term. This can be explained as follows. The regression attempted to find a solution to the following equation:

$$O\&M_t=\alpha_0+\alpha_1 SHIPS+\alpha_2 TOTALPERSONNEL+\epsilon_t$$

Breaking up the Total Personnel term into its two components gives the equation:

$$O\&M_t=\alpha_0+\alpha_1 SHIPS+\alpha_2 MILPERS+\alpha_2 CIVPERS+\epsilon_t$$

Since civilian wages are a significant portion of O&M, the O&M term can be expanded to:

$$O\&M_t=\omega_c CIVPERS+\beta_{oth} OTHER$$

In this equation, ω_c is the average wage coefficient for Civilian Personnel and β_{oth} is the price coefficient for all of the other categories of O&M. Solving for CIVPERS gives the following relationship:

$$CIVPERS=\frac{O\&M_t}{\omega_c}-\frac{\beta_{oth}OTHER}{\omega_c}$$

One can see from the basic cost relationship that as ϵ_t gets larger $O\&M_t$ gets larger. In the last equation, if $O\&M_t$ gets larger, the CIVPERS term gets larger. This means that the error term of the basic cost relationship and Civilian Personnel are correlated and the method of simple regression using ordinary least squares results in biased and inconsistent estimators. Although the regression results were not as good using Military Personnel only, the fact that it introduces no bias to the solution leads to it being the better choice over Total Personnel. [Ref 14:pp. 155-158]

E. CONCLUSIONS

This chapter provides a useful example of how dependence on regression studies can lead to misleading conclusions if further analysis is not conducted. While regressions had attractive statistical properties, they made no sense logically. The conclusion was reached that lack of homogeneous data caused the erroneous results. The Naval Station was spending its O&M dollars in categories in different proportions during the period of study. With San Diego Naval Station taking on additional responsibilities as other bases are being closed or reduced in size, the factors driving O&M are shifting away from ships and number of personnel. This seems to have had the most impact on the regression results. The lack of sufficient data points to conduct advanced analysis was a restriction on the analysis side and not a cause of the unexpected results. The retention time of financial records does not allow for enough years of data to conduct sufficient analysis. Future studies can utilize the data obtained for this study to supplement additional information that is collected. The simultaneous equation problem was evident in the results being better when the civilian personnel level was included in as Total Personnel. With a better understanding of these causes, future studies can continue, taking these considerations into account.

CHAPTER V. ADDITIONAL MODELS AND POSSIBLE OPTIONS

A. INTRODUCTION

Chapter IV determined that the regression analysis of the Naval Station data was misleading and could not be relied upon in this case for predicting O&M costs. As an alternative, some existing models will be introduced and discussed as to their effectiveness in predicting costs at the micro-level that we are seeking. Also, some possible relationships will be suggested to support the effort to obtain a workable cost relationship. The chapter will end with some conclusions on these discussions.

B. OTHER MODELS

There are two other models that are available that have not yet been mentioned. Their purposes are not directly intended for projecting yearly base O&M costs for budget use, but their structure may give some indications of the expected expenses. The models are the Cost of Base Realignment Actions (COBRA) model and the Air Force's Base Opening Package (BOP).

1. COBRA Model

The COBRA model is a tool used to evaluate the net present value of base closure alternatives. It uses standardized calculation methods to determine the financial implications of a base closure. The inputs require standard factors, site-specific, and scenario-specific data. [Ref 15:pp. 25-31] Standard factors are inputs that are common across the range of installations. Site-specific items take into account the size of the base and its normal budget. The scenario-specific data are dependent on the scope of the closure option being evaluated. A recent study of this model included a regression analysis of nine naval stations. The data was taken at one point in time across the different installations. The study involved relating base BOS expenses to Total Personnel levels. The civilian payroll portion of BOS was not included in the relationship. The fitted regression equation, obtained in the COBRA study to evaluate the accuracy of the model was: [Ibid:p. 74]

$$OBOS(\$\,thosands) = 11138 + 0.505\,TotalPersonnel$$

OBOS is the BOS value less civilian payroll and TotalPersonnel includes both military and civilian manpower.

One of the data observations used in the COBRA study was San Diego Naval Station. A point worth mentioning is that the total personnel value used is 35,935 [Ibid:p. 133]. This is clearly more than the number of personnel assigned to the Naval Station directly. Although there is no discussion of what is included, the total most likely includes the number of personnel assigned to tenant commands and even possibly those stationed on homeported ships at the base. This is significantly different than the method this thesis utilized in determining manning level.

The value used for non-payroll BOS was $24.8 million [Ibid] which is reasonably close to the value this study obtained for the Naval Station, less civilian pay. The method of taking out civilian pay from O&M is a good method that avoids the bias that was discussed earlier in this chapter. It would be interesting to plot this study's O&M vs personnel against the COBRA study regression line but since the personnel numbers are not calculated in the same manner, the plot will not provide any useful information.

The coefficient of $11,138K in the COBRA study regression indicates the fixed cost of running the base. Because of the non-homogeneous data in this study a good estimate for fixed costs is not available, but the $11 million from the COBRA study appears reasonable. The conclusion in the COBRA study found that the regressior results obtained are acceptably within the predictions achieved using the COBRA model. Regrettably, however, the COBRA study is not of more use in this thesis because of the different personnel level measures.

2. Air Force Base Opening Package

The Air Force Base Opening Package (BOP) is a model developed by the Air Force many years ago. Although dated 1969 and not of much practical use today, the structure and method of the model may be of use in determining what to consider when starting up a base and projecting the needed manpower. The methodology used in the model could be used to estimate the fixed cost of the naval station.[4]

TABLE 13: BOP MANNING STRUCTURE [Ref 16:p. 33]

Unit	Officer	Enlisted	Civilian	Total
Combat Support Group	29	189	36	254
Security Police Squadron	2	30	28	60
Supply Squadron	8	93	64	165
Services Squadron	3	61	14	78
Transportation Squadron	3	61	14	78
Civil Engineering Squadron	6	150	137	293
Medical-Dispensary	11	42	1	54
Other	9	143	8	160
Total	71	755	371	1197

Table 13 shows the model for manning the Air Force Base depicted in this model. Again, this is an old model and the fact that it is of another service is not of importance. The purpose of presenting this model is to illustrate what the manning structure is based upon and what are the driving factors. The design of this "model" is built around the

[4]The BOP was obtained from Mr. Gary Massey of the Rand Corporation, Santa Monica, CA.

following assumptions; supporting an assigned three squadron, 72 UE tactical fighter wing with aircraft flying .9 sorties per day. The base should have the surge capability to handle 60 flying hours per month per aircraft. Each aircraft will have a crew ratio of 1.25 crews per aircraft. Design of this base takes into account some of these factors: [Ibid:pp. 2-7]

- Acreage - approximately 5000 acres
- Airfield Pavements - 150' x 10,000' (for navy use piers would be a similar item)
- Hangers - 325,000 sq ft to support 72 fighter-type aircraft
- Electrical Distribution - 1.2 million linear feet of distribution line.
- POL - 200,000 barrels
- Warehousing - 150,000 sq ft
- Vehicles - 221 vehicles of various types

Since these are some of the important considerations when designing a base, perhaps these same types of factors could be used in developing a relationship to O&M expenses for an existing base. Listed below are some possible examples of independent variables for the Navy that could be interesting topics for further study in determining is such relationships exist.

- Square footage of base facilities, including tenant commands.

- Number and types of ships supported (This can be done in a manner of ways; size of crew, capital value, tonnage, etc).

- Operating days of ships: This would account for how many days the ship operated "cold iron" and received its support from the base, or operated in a "modified" configuration, providing some of its own support.

- Number of piers supported.

- Total personnel assigned to the naval station (include tenant commands and ship crews).

There are many different relationships that could be developed. The point is, the Air Force models used in this study appear to be based on such relationships. If the Navy could develop the same type of model that could predict costs at a micro-level it would provide useful information, not only for budget formulations but also for base opening or closing decisions.

C. APPLICATION EXAMPLES

Using the information provided in the previous sections of this chapter, some possible relationships will be discussed and evaluated for possible use as an O&M cost forecaster. Although no data is available to support or disprove these suggested correlations, the models will be discussed on a general basis only. Future studies can evaluate the suggested forecasting tools in greater detail with gathered data.

It is first important to have an understanding of the fixed cost of running the base. This is the personnel and infrastructure absolutely necessary to function properly. The Air Force Base Opening Package is a good place to start in determining the fixed cost of running the base. For a more specific estimate, the $11 million established from the COBRA study can provide a starting point. The fixed cost for each base will fluctuate from this "$11 million" estimate. Perhaps some type of ratio could be used, relating size of the base, such as square footage, number of ships supported, or personnel level assigned, to a standard corresponding to the $11 million fixed costs. Once the fixed cost is established, anything above that can be considered variable and O&M can be adjusted according to the fluctuation of selected indicators.

One possible relationship that can be used to establish the variable cost rate is using the capital value of ships homeported at the base. The capital value in this case will be the acquisition cost of the ships on a constant dollar basis. The form of the relationship would be as follows:

$$\frac{KV_i}{KV_{tot}} = \frac{O\&M_{baseivar}}{O\&M_{basetvar}}$$

The term on the left relates the capital value of a ship to the value of all ships supported by the base. This would be assumed as proportional to the ratio of O&M the base uses in support of the additional unit to the total variable O&M costs. Once a figure is obtained for the O&M support required for individual ship types, the adjustment to total O&M can be made as ships are added or taken away from the naval station.

Another type of relationship could utilize the ratio of ships' O&M to the total O&M of ships at the naval station. Some items would need to be removed such as overhaul and intermediate level maintenance costs performed on base since they are not a part of naval station O&M. The equation would look something like this:

$$\frac{O\&M_i - OVHL\&MAINT_i}{O\&M_t - OVHL\&MAINT_t} = \frac{O\&M_{baseivar}}{O\&M_{basetvar}}$$

A total of personnel ratio, either by ship or for the base or of the entire complex as a whole could be used. The relationship could look something like the following equation:

$$\frac{PEOPLE_i}{PEOPLE_t} = \frac{O\&M_{baseivar}}{O\&M_{basetvar}}$$

This makes personnel the driving factor in determining the variable O&M experienced by the naval station. Here, the term on the right would be a ratio of the O&M provided for the additional person to the total variable O&M.

These are only a few of the many relationships that could be explored and evaluated for accuracy in prediction. The common objective is to establish a measurable relationship that can be used to determine the impact on variable O&M. It was shown earlier in Chapter III how the Air Force utilized relationships of personnel, number of aircraft, and number of operating days in estimating O&M costs. Perhaps the Navy could attempt to derive a similar relationship using personnel, number of ships, and ship operating days. The big difference here is when an aircraft operates, it receives support from the base. The ship is virtually on its own when it operates, therefore receiving virtually no support from the base. The best solution in this case would be to use the ships operating time to explain base O&M, as is being done in the prototype BOS VAMOSC.

Of the three possible relationships given, the recommended one for use in estimating costs for San Diego Naval Station would be relating individual ship O&M to the level of base support it receives. The reason for that is most of the data is already available. VAMOSC data already tabulates O&M costs for ships, both individually and averaged across ship type. The largest assumption in this case is determining the amount of base support that is applicable to ships. For San Diego Naval Station the problem is minimized since it handles such a large volume of ships. A study would have to estimate relationship using total O&M over a period of time. To avoid the problems encountered in Chapter IV, spending anomalies should be factored out in order to get a better foundation of O&M attributable to ships. Once an estimate was determined for the marginal O&M attributable to the individual ship, future total O&M costs can be projected as number of ships change.

A relationship of this nature is not applicable Navy-wide. Different levels of ship activity will cause the ratio of O&M per ship to differ between home ports. This was shown in the example comparing San Diego Naval Station and Alameda Naval Air Station in Chapter III. The O&M rates for Alameda were nearly three times that of San Diego. Until a method can separate out the base O&M costs that are attributable to ships these differences will occur. A separate O&M relationship will have to be calculated for each base.

D. SUMMARY AND CONCLUSIONS

The COBRA model study was evaluated to determine if the regression testing provided a useable relationship for this study. The study showed an improvement in the regression technique used in Chapter IV by removing the payroll portions of O&M from the dependent variable and using cross sectional data across bases. Removing the payroll portions of O&M takes care of the simultaneous equation problem. The separation of civilian payroll from O&M was a good procedure and could be implemented in further studies in this field. Although a good equation was obtained, the method of determining Total Personnel was unclear and unusable for this study. The Air Force Base Opening Package provided some examples of what factors are important when developing a new base. Some of these items can be carried over to the naval service and an attempt to develop a relationship between them and O&M could make for interesting future studies.

Some examples of possible cost prediction relationships were given using capital values of ships, O&M used to support the ships themselves, and number of personnel. Some effort would have to be made to obtain these numbers but once the relationships were established for a ship type or personnel or ship O&M dollars, the ratios could be used to adjust base O&M as the specifics of the situation dictate.

The relationship using ship's O&M to determine base O&M attributable to an additional ship was recommended as a possible method for estimating San Diego Naval Station's O&M costs. This would only be applicable to the base. Other facilities would have to determine their own relationships, based upon the manner in which ships are supported.

CHAPTER VI. SUMMARY AND CONCLUSIONS

A. INTRODUCTION

This section contains a summary of this thesis, broken down by chapter. That will be followed by conclusions based upon the study. In conclusion, a section listing recommended topics for further research to continue this line of research is provided.

B. SUMMARY

Chapter I gave the purpose of this study which is to investigate the effect of personnel level changes on O&M expenditures at San Diego Naval Station. The motivation for this study was a Congressional reduction of the Navy's O&M appropriation due to the Navy's budget reflecting a personnel end strength 15,000 greater than the actual manning figure. This amounted to approximately 2.9 percent fewer personnel than the budget accounted for. Based upon this Navy budget proposal, the Senate Appropriations Sub-Committee reduced the Navy O&M by $50 million, a decrease of about .25 percent. One question to be answered by this study was what is the appropriate reduction that should have been made by Congress? Another related question was whether the amount of reduction imposed by Congress at the service-wide level is warranted at the naval station level? It was discussed how possible answers to these questions could be found by studying San Diego Naval Station's O&M data to determine what, if anything, drives the O&M expenses. Finding a useful relationship could help in predicting future budget needs.

Chapter II contained a macro-level analysis of the problem. A cost prediction model, Quick Cost, was used to examine the relationship of Navy O&M dollars to different levels of personnel. The model was described, showing how it was designed to give a cost estimate based on a hierarchical defense structure. Some limitations of the model were discussed. It is noted that the model was driven by changes in force levels of ships and aircraft. Since the purpose of this study was to find the impact of personnel reductions on O&M, the reduction was made by imposing a cut in ships, which in turn caused a personnel reduction. The assumption made was that a force-wide personnel cut would have to be accompanied by some proportional number of ships. The results of the model showed a nearly one-to-one relationship in percentage reduction in base O&M to percentage change in base personnel. This does not explain the reduction imposed by Congress, in which was there was a .25 percent O&M reduction associated with a 2.9 reduction in total manning.

Chapter III provided information concerning the Navy's VAMOSC data base and its limitations in this case. The data base was compared to the Quick Cost model to determine the extent of coverage. Since Base O&M is not included as a portion of Navy VAMOSC, it was considered inappropriate for use in this study. Some discussion was included to demonstrate how the VAMOSC data could be used if the O&M data were included, using a method similar to that of Quick Cost by entering an input based on number of ships affected. A prototype study of Navy VAMOSC that does include Base Operating Support was summarized, providing the elements of BOS that were evaluated for inclusion in future VAMOSC tables.

The Air Force CORE model and VAMOSC were then discussed, showing how they include Base O&M and how the costs are estimated using an algorithm containing total personnel, square footage and aircraft operating time. This was done to provide an example of how the Navy could approach estimating O&M costs associated with a naval station.

Chapter IV contained a micro-level analysis of O&M spending, using data collected from San Diego Naval Station. A regression analysis was performed relating O&M costs to numbers of Total Personnel, Total Military and Ships Supported. A multiple regression was also conducted using Total Personnel and Ships Supported together, in an attempt to obtain a better relationship. The surprising result of this chapter was a negative relationship of O&M spending to personnel levels and number of ships supported. This led to the conclusion that regression analysis in this case could be misleading. A critique of the regression pointed out problems with lack of homogeneity of data, limited data and the existence of simultaneous equations.

Chapter V introduced additional models to help find a way to estimate O&M requirements. A COBRA model study contained a regression study on a more macro-level providing a relationship of O&M to Total Personnel. The O&M figure obtained did not include civilian pay, which removes the simultaneous equation problem. Total Personnel included more than the assigned level at the base, most likely counting those at tenant commands and possibly even the personnel assigned to home ported ships. The O&M estimate with a fixed cost of about $11 million for San Diego Naval Station seems reasonable. Further analysis, however, of the topic is appropriate.

The Air Force Base Opening Package was discussed to show factors considered in determining the number of personnel assigned to a base. These items, which include square footage, aircraft operating hours, number and size of runways, and number of support vehicles to name a few were mentioned to suggest that Navy might also find relationships to O&M dollars used by the base.

Some possible cost prediction relationships were provided to estimate the impact on base O&M using a variable cost rate. The relationships included ratios of capital value of ships home ported at the naval station to the base O&M required to support the ships. Another relationship compared ships O&M to the base O&M required to support the ships. A third relationship was a ratio of personnel, regardless of whether the amount is amount assigned to the base, ships or the entire naval station complex. This ratio provided the amount of base O&M required for each additional person.

The relationship using individual ship O&M to determine base support attributable to the ship was recommended for the San Diego Naval Station. However, there should first be a study estimating the base O&M associated with each individual ship. Once calculated the factor could then be used in estimating the change in base O&M due to a change in number of ships.

C. CONCLUSIONS

1. Macro-level Analysis

While the Quick Cost model shows that changes in force structure result in less than proportional change in manning and O&M at the base level, it is still unclear precisely how a reduction in total Navy personnel is related to a reduction in manning and O&M at the base level. This may be due to the structure of the model not allowing for a direct input of personnel reduction. There is no evidence from this study to support or disprove the amount of O&M reduced at the macro-level.

2. Micro-level Analysis

The study of San Diego Naval Station O&M expenses by regression method is misleading in this case. The negative relationship of O&M to Total Personnel and Ships Supported should not be applied across the board on a macro-level. Regression should not be employed until a homogeneous population base of O&M data can be obtained. Although numbers of ships supported and personnel have decreased at a naval station, other factors must be considered when determining the amount of support money necessary. It may not necessarily correspond with the amount adjusted on the macro-level.

3. Cost Prediction Model

There was no acceptable relationship confirmed in this study, although some good options were provided. The recommended method for estimating a O&M cost driver for San Diego Naval Station is the relationship using ship O&M to determine the base O&M used to support it. Following verification by separate study, this or other models may be found appropriate for use in predicting costs. The relationship may be based upon square footage, number of personnel and/or ships, size of ships (either in tonnage, capital value, or crew size), ship operating time in port, or any other variable that is appropriate. Once such a relationship is determined and verified as acceptable, O&M costs may be predicted with a fair degree of accuracy.

Additionally, this creates a better method for charging customers utilizing base services.

D. SUGGESTED TOPICS FOR FURTHER RESEARCH

The following topics are recommended for further research in this area of study:

- Conduct a similar O&M study using the new data base for the Quick Cost model. This revision contains new Fixed/Variable figures covering the time frame of the Navy's down sizing.
- Continue the micro-level study of San Diego Naval Station to find a relationship of O&M costs. Utilize new data to add to data of this study to create a larger data base.
- Select a possible cost driver such as square footage or operating hours and conduct a micro-level study to determine its feasibility as a prediction tool.
- Once the Navy VAMOSC does incorporate BOS data, conduct a micro-level study to verify the reliability of the expanded VAMOSC as a prediction model.

APPENDIX A. **<u>QUICK COST</u> HIERARCHICAL STRUCTURE** [Ref 3:p. 13]

PROXY USED TO
DISTRIBUTE RESOURCES

	Units	Budget Authority (Dollars): Military Pay	Budget Authority (Dollars): Total O&M	Budget Authority (Dollars): Civilian Pay O&M Only	Budget Authority (Dollars): BTL Procurement	Officer End Strength in Aviation AE's	Military End Strength
Primary	✔						
Related		✔					
Auxiliary		✔					
MSF Force Training		✔					
Mgt. HQ-Combat		✔		✔			
BOS-Combat		✔	✔				
CSF Flight Training						✔	
Central Logistics			✔		✔		
Individual Training		✔					
BOS-Support		✔	✔				
Central Spt. Act. and Mgt. HQ-Support		✔		✔			
Medical and Personnel Support		✔					
Miscellaneous							✔

Relationship of AEC's and Allocation Variables

SOURCE OF Δ DATA USED TO APPLY PROXY

	Primary	Related	Auxiliary	MSF Force Training	Mgt. HQ-Combat	BOS-Combat	CSF Flight Training	Logistics	Training	BOS-Support	Mgt. HQ-Support	Medical/Personnel Support
Primary												
Related	✔											
Auxiliary	✔											
<u>MSF</u> Force Training	✔	✔										
Mgt. HQ-Combat	✔	✔	✔	✔								
BOS-Combat	✔	✔	✔	✔	✔							
<u>CSF</u> Flight Training	✔	✔	✔	✔	✔	✔						
Central Logistics	✔	✔	✔	✔	✔	✔	✔					
Individual Training	✔	✔	✔	✔	✔	✔	✔	✔				
BOS-Support	✔	✔	✔	✔	✔	✔	✔	✔	✔			
Central Spt Act. and Mgt. HQ-Support	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔		
Medical and Personnel Support	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	
Miscellaneous	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔

Inter-AEC Relationships

APPENDIX B. SAN DIEGO NAVAL STATION EXPENSE DATA [Ref 1]

Sub Activity Group Listing (SAG's)

FA	Maintenance and Repair of Real Property (MRP)
FB	Minor Construction
FC	Operation of Utilities
FD	Other Engineering Support
FF	Administrative
FG	Retail Supply Operations (Purchasing)
FH	Maintenance of Installation Equipment
FJ	Bachelor Housing Operations and Furnishings
FK	Other Personnel Support
FL	Morale, Welfare, Recreation
FN	Base Communications
FQ	Base Operations (ADP)
FR	Other Base Services
FT	Hazardous Waste
FV	Physical Security
FX	Environmental
LD	Family Service Center
LR	Child Care
RA	Federal Employee Compensation Act
V2	Other Audio Visual Support

Expense Element Listing (EE's)

D	Purchased Equipment Maintenance (Intra-DOD)
E	Travel of Personnel
J	Transportation of Things, Inland Transportation
M	Utilities and Rents
N	Communications
P	Purchased Equipment Maintenance (Commercial)
Q	Purchased Services (Other)
T	Supplies
U	Civilian Personnel
V	Other POL
W	Equipment
Y	Printing and Reproduction

EXPENSE BREAKDOWN (THEN YEAR DOLLARS)

SAG	EE	FY 89	FY 90	FY 91	FY 92	FY 93
FA	M		$200		$57,604	
FA	P	$17,853	$23,040	$41,644	$26,840	$8,920
FA	Q	$6,812,247	$6,362,883	$8,817,316	$8,557,342	$8,904,482
FA	T	$266,009	$378,819	$624,643	$1,571,767	$1,626,392
FA	V	$35	$23		$2,062	$1,000
FA	W	$22,369	$654	$8,897	$32,568	$19,910
FB	M	$488		$8,475	$746	$127,121
FB	Q	$623,924	$620,429	$829,801	$958,977	$1,096,980
FB	T	$16,290	$31,472	$95,864	$111,444	$147,615
FB	W				$74,697	
FB	V					$100
FC	M	$3,560,808	$3,479,689	$3,021,446	$3,728,680	$3,923,020
FD	E	$758	$811	$3,137	$289	$3,300
FD	M	$33,448	$18,623	$29,807	$51,365	$20,693
FD	Q	$2,818,072	$2,891,772	$3,067,797	$2,157,373	$3,585,733
FD	T	$106,647	$148,889	$175,556	$399,426	$361,629
FD	U	$269,554	$313,449	$374,215	$396,997	$390,834
FD	W				$148,046	$51,728
FD	Y	$400			$718	$584
FF	E	$26,308	$20,689	$8,170	$17,955	$26,945
FF	M	$6,642	$6,642	$8,489	$11,295	$1,104
FF	N				$329	
FF	P	$39,143	$51,352	$28,667	$37,138	$33,468
FF	Q	$21,801	$57,100	$25,580	$37,776	$67,965
FF	T	$87,481	$114,661	$146,824	$216,296	$191,666
FF	U	$2,107,192	$2,431,434	$1,996,663	$1,948,506	$2,032,279
FF	W	$67,766	$50,484	$137,650	$417,750	$26,046
FF	Y	$10,230	$9,612	$8,467	$5,695	$6,775
FG	E					$1,800
FG	P	$4,118	$3,005	$2,806	$2,290	$2,386
FG	Q	$3,522	$1,080	$2,331	$2,448	$32,760
FG	T	$10,565	$243,847	$70,354	$22,226	$3,705
FG	U	$217,507	$215,867	$267,893	$318,734	$188,144
FG	Y	$183	$215	$885	$1,658	$340
FH	D	$19,625	$12,370	$57,161	$19,000	$33,595
FH	E	$249,428	$322,957	$255,425	$383,990	$275,831
FH	M	$655				
FH	P	$5,481	$5,754	$6,452	$6,313	$6,520
FH	Q		$6,700		$2,694	$15,455
FH	T	$150,670	$241,979	$136,736	$289,361	$183,621
FH	U	$133,187	$133,226	$157,897	$184,604	$191,629

FH	W				$449	
FH	Y	$3,241	$796	$4,112		
FJ	E	$2,139			$497	$4,948
FJ	M			$14,422	$4,367	
FJ	P	$8,594	$3,591	$10,700	$257	$119
FJ	Q	$345,671	$191,814	$218,373	$217,431	$267,623
FJ	T	$554,339	$543,276	$420,136	$576,717	$866,909
FJ	U	$28,068	$30,583	$32,284	$84,175	$112,101
FJ	W	$688,863	$151,473	$258,274	$250,399	$551,913
FJ	Y	$7,974	$2,579	$7,672	$3,241	$8,142
FK	E	$6,380	$9,974	$20,978	$99,892	$8,461
FK	M	$9,651	$10,743	$8,075		
FK	P	$2,752	$3,046	$9,672	$8,376	$8,772
FK	Q	$1,931,666	$2,085,454	$2,212,395	$2,356,346	$1,405,829
FK	T	$162,369	$144,829	$174,043	$155,759	$172,341
FK	U	$871,655	$938,133	$1,128,762	$409,286	$392,615
FK	V					$500
FK	W		$76,539	$57,147	$12,074	$29,545
FK	Y	$5,408	$3,012	$5,863	$1,949	$4,483
FL	E	$463		$836	$498	$377
FL	P	$836	$734	$109	$1,563	$311
FL	Q	$313,630	$645,815	$1,413,726	$12,081	$10,725
FL	T	$36,211	$30,665	$26,080	$235,267	$256,620
FL	U	$109,896	$152,576	$151,300	$105,398	$119,815
FL	W		$499	$577	$112,361	$56,793
FL	Y	$134			$64	
FN	N	$752,546	$493,535	$474,115	$637,371	$702,346
FN	P	$11,883	$11,236	$18,724	$8,169	$6,774
FN	Q	$36,037	$117,084	$99,404	$103,717	$104,334
FN	T	$1,768	$447	$2,206	$3,371	$7,008
FN	W	$9,557	$13,639	$11,571	$39,112	$20,340
FQ	E	$3,973	$14,176	$2,130	$1,515	$587
FQ	P	$14,894	$900	$2,174	$1,455	
FQ	Q	$301,476	$369,716	$420,467	$76,275	$153,089
FQ	T	$117,501	$96,420	$83,585	$175,109	$139,017
FQ	U	$122,021	$172,502	$268,207	$262,624	$278,732
FQ	W	$95,702	$25,279	$18,446	$134,266	$148,977
FR	E	$741,872	$621,749	$649,384	$723,591	$328,940
FR	M	$11,254	$1,520	$21,836	$19,958	$3,965
FR	P	$23,439	$25,974	$21,473	$14,500	$10,750
FR	Q	$5,109,424	$4,575,766	$4,998,260	$4,004,520	$3,138,054
FR	T	$187,137	$209,354	$138,933	$266,876	$309,247
FR	U	$1,396,869	$1,079,916	$1,274,021	$1,517,239	$1,674,317
FR	V	$78,812	$57,233	$80,994	$132,088	$126,509
FR	W	$74,724	$35,018	$4,690		$59,834

FR	Y	$4,238	$7,716	$2,311	$744	$530
FT	E				$998	$1,412
FT	Q		$524,923	$1,326,452	$472,692	$692,712
FT	T				$31,140	$9,086
FT	U				$58,521	$38,998
FT	Y				$243	$1,015
FV	E	$4,955	$224,420	$352,652	$616,079	$242,608
FV	J		$1,012	$1,312		
FV	M		$8,427	$100	$13,216	$14,483
FV	P	$2,514	$12,721	$37,841	$14,910	$4,753
FV	Q	$11,398	$84,405	$167,174	$80,979	$83,309
FV	T	$74,414	$63,041	$270,589	$196,051	$115,961
FV	U	$2,236,807	$2,645,112	$3,181,430	$2,801,322	$2,597,200
FV	V	$500		$4,000	$1,118	$2,564
FV	W	$54,399	$8,640	$148,012		$13,151
FV	Y	$28,363	$16,665	$14,216	$20,946	$11,426
FX	E			$6,114	$4,030	$5,058
FX	M					$809
FX	Q			$230,590	$302,810	$412,121
FX	T			$621	$8,358	$6,268
FX	U			$69,978	$55,761	$92,581
FX	W					$2,283
LD	E				$4,828	$5,237
LD	M				$43,588	$46,903
LD	N				$23,925	$37,369
LD	P				$1,955	$3,042
LD	Q				$144,326	$52,776
LD	T				$54,567	$139,187
LD	U				$515,535	$721,323
LD	W				$43,954	$70,399
LD	Y				$1,450	$2,245
LR	E				$3,362	$8,432
LR	M				$46,784	$16,410
LR	N				$19,430	$20,061
LR	P				$999	$4,215
LR	Q				$331,913	$117,826
LR	T				$127,515	$268,798
LR	U				$1,285,804	$1,463,989
LR	W				$30,291	$60,874
LR	Y				$46	
RA	Q			$50,801	$48,543	$31,228
V2	Q				$224	$139
V2	T	$2,857	$2,769	$8,342	$6,607	$9,948
V2	W	$2,337	$6,707	$3,479	$14,539	$9,228
V2	Y				$325	

EXPENSE BREAKDOWN BY SAG (THEN YEAR DOLLARS)

	FY 89	FY 90	FY 91	FY 92	FY 93
Maintenance and Repair of Real Property (MRP)	7,118,513	6,765,619	9,492,500	10,248,183	10,560,704
Minor Construction	640,702	651,901	934,140	1,146,864	1,371,816
Operation of Utilities	3,560,808	3,479,689	3,021,446	3,728,680	3,923,020
Other Engineering Support	3,228,879	3,373,544	3,650,512	3,164,214	4,414,501
Administrative	2,366,563	2,741,974	2,360,510	2,692,740	2,386,248
Retail Supply Operations (Purchasing)	235,896	464,014	344,269	347,356	229,135
Maintenance of Installation Equipment	562,287	723,782	617,783	886,411	706,651
Bachelor Housing Operations and Furnishings	1,635,648	923,316	961,860	1,137,084	1,811,755
Other Personnel Support	2,989,881	3,271,730	3,616,935	3,043,682	2,022,546
Morale, Welfare, Recreation	461,170	830,289	1,592,628	467,232	444,641
Base Communications	811,791	635,941	606,020	791,740	840,802
Base Operations (ADP)	655,567	678,993	795,009	651,244	720,402
Other Base Services	7,627,769	6,614,246	7,191,902	6,679,516	5,652,146
Hazardous Waste	0	524,923	1,326,452	563,594	743,223
Physical Security	2,413,350	3,064,443	4,177,326	3,744,621	3,085,455
Environmental	0	0	307,303	370,959	519,120
Family Service Center	0	0	0	834,128	1,078,481
Child Care	0	0	0	1,846,144	1,950,605
Federal Employee Compensation Act	0	0	50,801	48,543	31,228
Other Audio Visual Support	5,194	9,476	11,821	21,695	19,315
Total	34,314,017	34,753,880	41,059,217	42,403,630	42,521,794

EXPENSE BREAKDOWN BY EE (THEN YEAR DOLLARS)

Purchased Equipment Maintenance (Intra-DOD)	19,625	12,370	57,161	19,000	33,595
Travel of Personnel	1,036,276	1,214,776	1,298,826	1,867,524	913,936
Transportation of Things, Inland Transportation	0	1,012	1,312	0	0
Utilities and Rents	3,622,946	3,525,844	3,112,650	3,977,603	4,154,508
Communications	752,546	493,535	474,115	681,055	759,776
Purchased Equipment Maintenance (Commercial)	131,507	141,353	180,262	124,765	90,030
Purchased Services (Other)	18,328,868	18,534,941	23,880,467	19,868,467	20,173,140
Supplies	1,774,258	2,250,468	2,374,511	4,447,857	4,815,018
Civilian Personnel	7,492,756	8,112,798	8,902,650	9,944,506	10,294,557
Other POL	79,347	57,256	84,994	135,268	130,673
Equipment	1,015,717	368,932	648,743	1,310,506	1,121,021
Printing and Reproduction	60,171	40,595	43,526	37,079	35,540
Total	34,314,017	34,753,880	41,059,217	42,403,630	42,521,794

EXPENSE BREAKDOWN BY SAG (CONSTANT 1982-84 DOLLARS)

	FY 89	FY 90	FY 91	FY 92	FY 93
Maintenance and Repair of Real Property (MRP)	5.740.736	5.176.449	6.969.530	7.222.116	7.243.281
Minor Construction	516.695	498.777	685.859	807.516	940.889
Operation of Utilities	2.871.619	2.662.348	2.218.389	2.627.681	2.690.686
Other Engineering Support	2.603.935	2.581.135	2.680.258	2.222.843	3.027.778
Administrative	1.908.519	2.097.914	1.733.120	1.897.632	1.636.658
Retail Supply Operations (Purchasing)	190.238	355.022	252.767	244.789	157.157
Maintenance of Installation Equipment	453.457	553.774	453.585	624.673	484.671
Bachelor Housing Operations and Furnishings	1.319.071	706.439	706.211	801.328	1.242.630
Other Personnel Support	2.411.194	2.503.236	2.655.606	2.144.949	1.387.206
Morale, Welfare, Recreation	371.911	635.263	1.169.330	329.268	304.966
Base Communications	654.670	486.565	444.949	557.956	576.682
Base Operations (ADP)	528.683	519.505	583.707	458.946	494.103
Other Base Services	6.151.427	5.060.632	5.280.398	4.707.199	3.876.643
Hazardous Waste	0	401.624	973.900	397.177	509.755
Physical Security	1.946.250	2.344.639	3.067.053	2.638.915	2.116.224
Environmental	0	0	225.626	261.423	356.049
Family Service Center	0	0	0	587.828	739.699
Child Care	0	0	0	1.301.018	1.344.722
Federal Employee Compensation Act	0	0	37.299	34.209	21.418
Other Audio Visual Support	4.189	7.250	8.679	15.289	13.248
Total	27.672.594	26.590.574	30.146.268	29.882.755	29.164.468

EXPENSE BREAKDOWN BY EE (CONSTANT 1982-84 DOLLARS)

Purchased Equipment Maintenance (Intra-DOD)	15.827	9.464	41.968	13.390	23.042
Travel of Personnel	835.706	929.438	953.617	1.309.037	626.842
Transportation of Things, Inland Transportation	0	774	963	0	0
Utilities and Rents	2.921.731	2.697.662	2.285.352	2.803.103	2.849.457
Communications	606.892	377.609	348.102	479.954	521.108
Purchased Equipment Maintenance (Commercial	106.054	108.151	132.351	87.925	61.749
Purchased Services (Other)	14.781.345	14.181.286	17.533.383	14.001.739	13.836.173
Supplies	1.430.853	1.721.858	1.743.400	3.134.501	3.302.481
Civilian Personnel	6.042.545	6.207.191	6.536.454	7.008.109	7.060.739
Other POL	63.990	43.807	62.404	95.326	89.625
Equipment	819.127	282.274	476.316	923.542	768.876
Printing and Reproduction	48.525	31.060	31.957	26.130	24.376
Total	27.672.594	26.590.574	30.146.268	29.882.755	29.164.468

LIST OF REFERENCES

1. Interview between B. Brown, Budget Officer, San Diego Naval Station, San Diego, CA and the author 12-14 January 1994.

2. Senate Committee on Appropriations, *Report on the Department of Defense Appropriations Bill, 1994, No. 103-153*, October 1993.

3. Vassar, T., *Quick Cost, Defense Force Cost Model* and manual, 1991 edition.

4. Franck, R.E., Jr., and Hildebrandt, G.H., *Cost Estimation Methodology*, Appendix to *Alternatives for Defense in the Post-Soviet World*, Draft US Air Force Academy Technical Report, January, 1993.

5. Department of the Navy Report DD-I&L(A&AR) 1422 (SHIPS 5200), *Visibility and Management of Operating and Support Costs (VAMOSC) - Ships, Vol I, Individual Ships Report FY 1990*, March 1991.

6. Navy Center for Cost Analysis, Contract N00024-88-C-4013, TAR 90-002B2, *Prototype Base Operations Support (BOS) Cost Reports for Naval Ships*, 1 June 1990.

7. Department of the Air Force, Headquarters U.S. Air Force, Washington D.C. 20330-5000, *AF Regulation 173-13, U.S. Air Force Cost and Planning Factors*, 1 February 1985.

8. Department of the Air Force, Headquarters U.S. Air Force, Washington D.C. 20330-5000, *AF Regulation 400-31, Volume II*, 24 August 1982.

9. U.S. Bureau of the Census, *Statistical Abstract of the United States:1992 (112th edition)*, Washington D.C., 1992.

10. *Facts on File, World News Digest with Index*, Vol. 53, No. 2721, 21 January 1993.

11. *Facts on File, World News Digest with Index*, Vol 54, No. 2772, 13 January 1994.

12. Liao, S.S., *Regression Techniques for Managerial Planning and Control*, unpublished, 1994.

13. Pindyck, R.S., and Rubinfeld, D.L., *Econometric Models and Economic Forecasts*, McGraw-Hill Book Company, 1976.

14. Wonnacott, R.J., and Wonnacott, T.H., *Econometrics*, John Wiley and Sons, Inc., 1970.

15. Kemper, V.P., *An Analysis of the Cost of Base Realignment Actions (COBRA) Model*, Master's Thesis, Naval Postgraduate School, Monterey, CA, December 1993.

16. Department of the Air Force, *Typical Main Operating Base: "Base Opening Package"*, 1969.

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