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AN ANALYSIS OF OPERATING AND SUPPORT COSTS IN THE DEPARTMENT OF DEFENSE

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September 1993

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To better understand operating and support (O&S) costs within the DoD, IDA undertook a broad-based investigation of historical O&S costs. The following research questions were formulated: (1) Has O&S spending grown faster than the budget? (2) If O&S spending has grown, what has contributed to the growth? and (3) Do O&S costs grow for weapon systems over time? To address those questions, IDA investigated the relationship between forces and aggregate O&S costs for FY 1971 to 1990. That investigation indicated that O&S costs are growing and that the primary sources of growth are DoD's primary mission programs and direct support programs. In general, O&S cost per unit of force structure is increasing, while, for most classes of weapon systems, O&S cost per dollar of capital asset value is decreasing. IDA also performed cost studies of individual aircraft to assess cost growth during the development and procurement phases of the acquisition process. Information on the F-15 and F-16 fighter aircraft indicated that estimates of O&S cost tend to grow as a system progresses through development to production. Data on the F/A-18 program did not support this conclusion.

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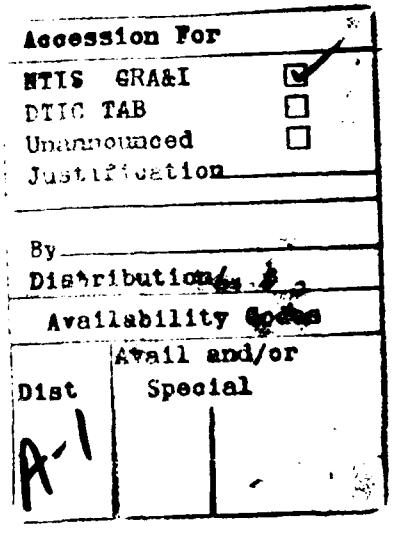
IDA Independent Research Program

PREFACE

This document was prepared by the Institute for Defense Analyses (IDA) under IDA's Independent Research Program. The objective of the task was to improve the understanding of the relationship between Operating and Support (O&S) costs and the forces they support.

This work was reviewed within IDA by Stanley A. Horowitz and James L. Wilson.



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SUMMARY

The purpose of this research effort is to improve the understanding of the ways in which operating and support (O&S) costs have changed over the last 20 years. The main focus is on the relationships between O&S costs and the forces they support. While our study was not intended to be comprehensive in the evaluation of these relationships, it did provide information on general trends and probe selected O&S cost issues. To gain insight into the general trends, we conducted a broad-based investigation of historical O&S costs that encompassed the dominant portion of the DoD program. To probe O&S cost issues, the study progressed from this overview down to the individual services, the missions of the services, the weapon systems responsible for completion of those missions, and infrastructure programs that support the mission programs.

Research questions were formulated to gain insight into the complex relationship between O&S costs and the forces they support. Three questions central to our investigation were:

(1) Has O&S spending grown faster than the budget?

(2) If O&S spending has grown, what has contributed to the growth?

(3) Do O&S costs grow for weapon systems over time (during acquisition and from one model to the next)?

The information reviewed in this study does not indicate that O&S spending has grown faster than the overall defense budget. Historical FYDP data indicate that O&S expenditures have totaled roughly 60 percent of the overall defense budget. O&S reached a high of 66 percent in 1975 and a low of 53 percent in 1984 and 1985. In constant FY 1992 dollars, total DoD O&S costs have increased 8 percent from about $158 billion in FY 1971 to $170 billion in FY 1990. As a percentage of total DoD expenditures, O&S spending has declined from 62 percent in FY 1971 to 58 percent in FY 1990.

The two areas where aggregate O&S expenditures increased are force structure and programs that provide direct support to force structure programs. O&S spending on primary mission programs increased 18 percent from $44 billion in FY 1971 to $63 billion in FY 1990. O&S spending on direct support programs increased 80 percent from $12 billion to $17 billion over this same period. A reduction in O&S spending from

$9 billion to $6 billion was experienced in other defense mission programs. O&S spending on DoD infrastructure in FY 1971 was essentially the same as that in FY 1990, about $96 billion. Infrastructure O&S spending during FY 1974 to FY 1990 appears to be closely related to O&S spending in mission programs.

The major results from our evaluation of Air Force primary mission program force structure and operating and support costs are fourfold: (1) O&S expenditures per unit of force structure have been increasing for every class of weapon system examined with the exception of tactical airlift aircraft, (2) the retirement of older aircraft and their replacement with fewer, more capable, and more costly aircraft is increasing capital asset value, (3) O&S expenditures are growing at a slower rate than the capital asset value of the aircraft inventory, and (4) there appear to be small savings in military manpower as new aircraft are introduced into the inventory.

For Navy strategic submarines, O&S expenditures have been growing at the rate of about 1 percent per year, while fleet force levels have been declining at about 1 percent yearly. The overall capital asset value of the fleet experienced a decrease, and the cost of supporting nuclear ballistic missile submarines (SSBNs) rose more rapidly than the cost of buying them.

For Navy general-purpose systems, tactical aircraft and the surface combatants force structure programs are examined. The tactical aircraft category encompasses all the mission-coded tactical combat aircraft, stationed at sea or on land, in the Navy's inventory. Surface combatants can be divided into two categories: (1) aircraft carriers and (2) cruisers, destroyers, and frigates.

For Navy tactical aviation, the cost results were similar to those for the Air Force: O&S costs and costs per unit of force structure rose, but the cost of supporting a fleet of aircraft of a given value fell dramatically.

Aircraft carriers displayed a high level of overall O&S growth. From 1971 to 1990, total O&S costs grew by over 40 percent with an annual growth rate above 3 percent. Nuclear-powered carriers grew from 7 percent of the fleet in 1971 to 43 percent in 1990. The net results of replacing conventional carriers with nuclear carriers has contributed to the high growth in O&S cost per aircraft carrier. The 3.6-percent annual increase in O&S cost has resulted in a 2.4-percent annual increase in the O&S cost per dollar of capital asset value.

The results of our analysis of cruisers, destroyers, and frigates show that as the force structure has been reduced, the O&S cost to support that force structure has

increased. The total funding consumed by 256 ships in 1971 was roughly $2.8 billion compared to the 1990 level of 200 ships, which consumed $4.1 billion. A complete set of capital asset (CA) values were not available for Navy ships that were in the inventory in the early 1970s, and for that reason, CA was not included in the regressions.

In summary, when it comes to tactical aircraft, the Navy is experiencing the same type of O&S cost trend as the Air Force. The total O&S cost for tactical aircraft is increasing, while the cost per dollar of the capital assets is decreasing. The Navy is experiencing a slight reduction in manpower per aircraft. However, the Navy's strategic missile submarine and aircraft carrier fleets are experiencing increasing O&S cost growth in excess of growth in capital asset value.

The analysis of O&S expenditures in the Marine Corps revolve around tactical fighter/attack aircraft. The results of the study show overall increasing O&S costs for Marine Corps aircraft, and an increase in force structure levels. Yearly increases in force structure average greater than 2 percent, while O&S costs increased at a rate of over 4 percent per year. This increase resulted in a 2-percent increase per year in the ratio of O&S costs to force structure size. While the Marine Corps experienced an absolute increase in its O&S costs, the data indicate that the Marine Corps spends less O&S funds per dollar of aircraft production cost. This is the same pattern we saw for Air Force and Navy aviation.

Direct support programs experienced a significant growth in O&S expenditures. These programs include war reserve materials, tactical missile procurement, mission-unique communications, decentralized training, and Joint Chiefs of Staff exercises. O&S expenditures for direct support programs averaged $11 billion during FY 1971–1980 and increased to an average of $17 billion during FY 1981–1991.

To address the question about whether or not O&S costs grow for weapon systems over time, we used two hypotheses as the basis for case study analysis. The first hypothesis was that estimates of O&S costs grow as weapon systems progress through the acquisition process from RDT&E to production. The information for the F-15 and F-16 support that hypothesis. The information reviewed for the F/A-18 did not. The second hypothesis was that O&S costs for newer, more complex aircraft would be lower than the O&S cost of the aircraft they are to replace. In the case of the comparison between the F-4 and the F-15 and F-16, the second hypothesis was supported. In the case of a comparison between the A-7 and the F/A-18, the second hypothesis was not supported. The A-7's O&S costs are about 80 percent of the F/A-18's.

I. INTRODUCTION

A. BACKGROUND

The past two decades have seen significant changes in the complexity and capability of most of the weapon systems used by the Department of Defense (DoD). To curtail the effect on cost of operating increasingly complex weapon systems, the DoD began in the 1970s to emphasize life-cycle costs, reliability, and maintainability. The objective was to field equipment that would be more affordable to operate and maintain. There are those who believe that, even with the increased emphasis on designing weapon systems to meet specified logistics support objectives, increased weapon system complexity has resulted in increased operating and support (O&S) costs across the DoD. Concerns about the effect of complex systems on O&S costs have raised several questions: Are O&S costs increasing across the DoD? Are O&S costs increasing for given levels of forces and for the weapon systems that equip those forces? Are the direct costs of supporting forces the only factor in increasing O&S costs; in particular, are O&S costs associated with DoD infrastructure functions increasing?

To gain insight into the effect of introducing more complex weapon systems, an understanding of the historical relationships between O&S costs and the forces they support is of value to the DoD. Because of fiscal constraints being placed on DoD programs, the ability to assess the cost and operational effect of new systems and emerging technologies will become increasingly important. An improved understanding of these relationships is needed so that future decisions can be made based on affordability by assessing the cost of achieving a given level of capability. In the future, the DoD will make decisions about whether to extend the life of current systems through modification or to purchase new systems. The cost of operating and maintaining alternative systems will play an important role in such decisions.

B. OBJECTIVE

The purpose of this research was to improve the understanding of the ways in which O&S costs have changed over the last 20 years. The main focus is on the relationships between O&S costs and the forces they support. While the study is not

intended to be comprehensive in the evaluation of these relationships, it will provide information on general trends and probe selected O&S cost issues identified in the study. To gain insight into the general trends, we conducted a broad-based investigation of historical O&S costs that encompassed the dominant portion of the DoD program. To probe O&S cost issues, the study progressed from this broad overview to the individual services, the missions of the services, the weapon systems responsible for completing those missions, and the infrastructure programs that support those missions.

C. APPROACH

Research questions were formulated to gain insight into the complex relationship between O&S costs and the forces they support. The questions central to our investigation were:

(1) Has O&S spending grown faster than the budget?

(2) If O&S spending has grown, what has contributed to the growth?

(3) Do O&S costs grow for weapon systems over time (during acquisition and from one model to the next)?

To address these questions, we performed a two-part study. In the first part, we addressed the first two questions by investigating the relationship between forces and aggregate O&S costs for FY 1971 to 1990. A macro-level review addressed the various elements that make up the DoD program, and a more detailed review addressed individual parts of the program.

For the second part of the study, we probed the system level to address the third question of whether or not O&S costs increase in specific weapon systems over time from the start of development through deployment, and between succeeding series or classes of systems. The growth of predicted O&S costs during development is of interest because it may contribute to the perception that O&S costs are out of control. The analysis of succeeding systems was meant to confirm insights about the interaction of O&S costs and technology. Case studies on a selected set of specific aircraft systems were performed to assess cost growth during the development and procurement phases of the acquisition process and between succeeding series of aircraft. The case studies cover the F-15, F-16, and F-4 fighter aircraft for the Air Force and the F-4, A-7, and F/A-18 aircraft for the Navy.

D. REPORT OUTLINE

This report is divided into five chapters. Following this introduction, Chapter II describes the separate methods used for the aggregate analysis (questions 1 and 2) and the case studies (question 3).

Chapter III presents the results of the aggregate analysis of O&S costs. This includes a review of the relationship between the total DoD program and O&S costs followed by a more detailed review of selected mission programs.

Chapter IV presents the results of the case studies with detailed reviews of the F-15, F-16, F-4, A-7, and F/A-18 aircraft.

Chapter V provides a summary and conclusion and presents recommendations for future research.

II. STUDY METHODS

Two separate methods were used in this study. For the analysis of aggregate O&S cost, a method based on specific research questions was developed to gain insight into the relationship between O&S costs and mission programs and other types of DoD programs. For the case studies, specific hypotheses were tested to assess the trends in aircraft O&S costs over time.

A. AGGREGATE O&S COST STUDY

This section describes the approach used to address aggregate O&S costs. The areas covered include the research questions, the overall DoD program analysis structure, and specific considerations about the data.

1. Research Questions

For this part of the study, the two dominant questions were as follows: (1) Has O&S spending grown faster than the budget? and (2) If O&S spending has grown, what has contributed to the growth? To address the second question, the following subordinate questions were explored:

(a) Has O&S spending grown faster than the forces they support?

(b) To what extent are O&S costs for direct support of the forces and to what extent are they due to spending on infrastructure?

(c) What is the role of technology in determining trends in O&S costs?

In order to answer these questions, a structure that separated the DoD program into mission programs and infrastructure programs was needed. Definitions were developed to classify different types of force structures, programs that exhibited O&S cost growth were identified, and information about the source of the cost growth was gathered.

2. Analysis Structure

The program analysis structure used in the study is presented in Figure II-1. The method by which we segregated the data was based on a taxonomy taken from an IDA study on total force policy [1]. Using this taxonomy, the total defense program can be

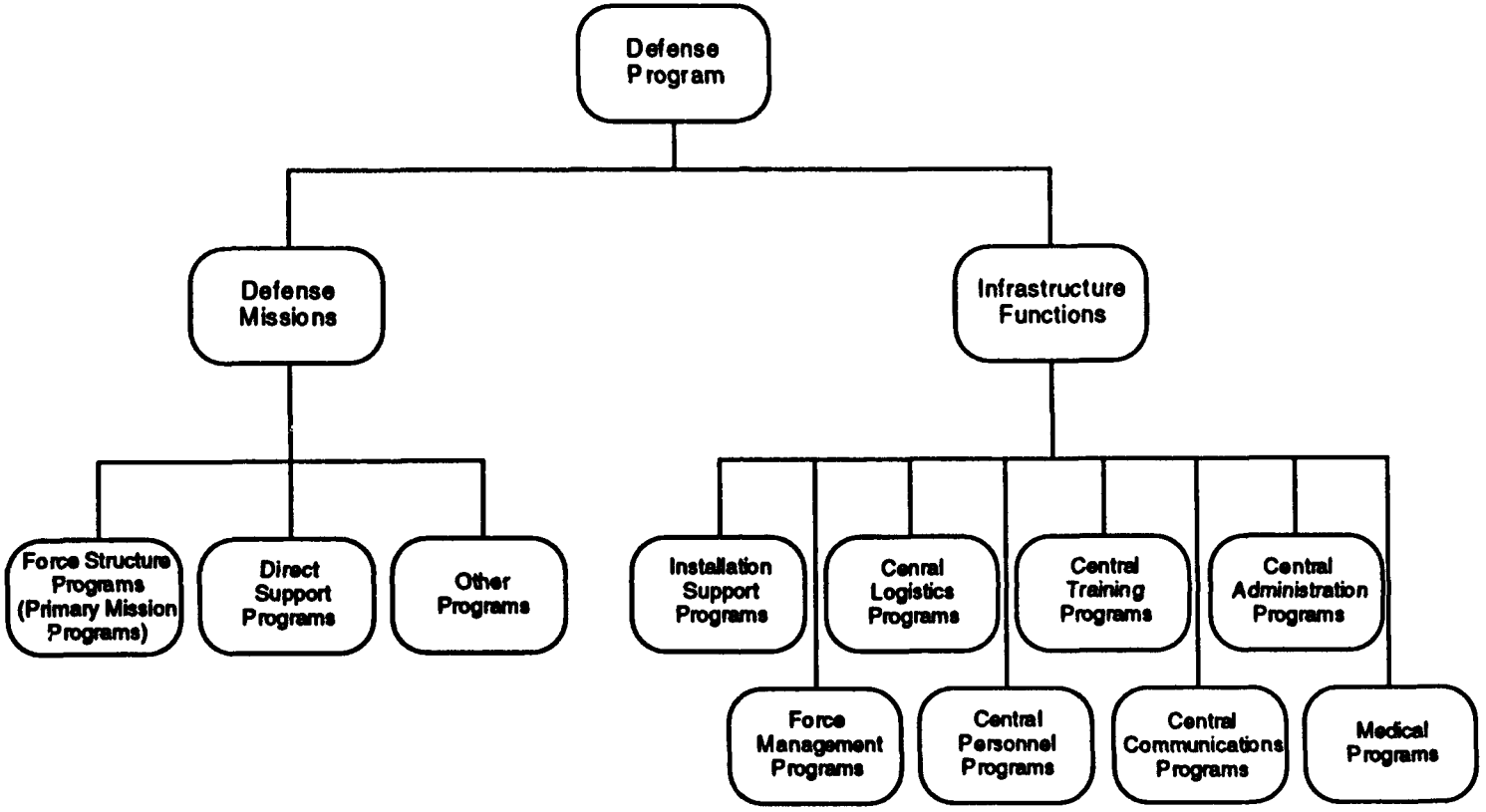

Figure II-1. Department of Defense Program Analysis Structure

divided into two major categories of program elements: (1) program elements that represent the force structure and resources for defense missions and (2) program elements whose primary purpose is to provide infrastructure functions (support) to the defense missions.

Defense mission programs can be subdivided into three major functional classifications (groups of related activities) consisting of force structure programs, direct support programs, and other programs. The first of these classifications, force structure programs, are referred to as primary mission programs throughout this report. These programs include all the major combat units across the services (e.g., Divisions, Marine Expeditionary Forces, Wings, etc.). Direct support programs, the second program classification, include war reserve material, tactical missile procurement, mission-unique communications, and decentralized training and Joint Chiefs of Staff (JCS) exercises. Examples of other defense mission programs, the third classification, are research, development, test and evaluation (RDT&E) programs, test ranges, and national command and control programs.

Infrastructure functions encompass the following programs: installation support, force management, central logistics, central personnel, central training, central communications, central administration, and medical. Such programs provide the underlying framework that enables the services to function efficiently and effectively.

We went through the Future Years Defense Program (FYDP) and categorized individual program elements by placing them in the appropriate classification, either defense missions or infrastructure functions.

Regression analysis was used to examine O&S spending trends for each of the four categories of programs (force structure, direct support, other defense missions, and infrastructure functions.) For the force structure programs, O&S spending trends were examined for selected classes of forces. Figure II-2 illustrates how we treated one mission area: strategic warfare. We moved from the strategic warfare mission, to the strategic offense sub-mission, to four classes of forces, and finally to individual weapon systems.

The following classes of forces were selected for further study: strategic bombers, strategic tankers, strategic airlift, Air Force tactical aircraft, Air Force tactical airlift, strategic submarines, Navy tactical aircraft, Marine Corps tactical aircraft, aircraft carriers, and cruisers, destroyers, and frigates. For each class, time trends in O&S spending (normalized for force structure changes in various ways) were developed. Separate adjustments were made for force size and for the capital asset value of equipment—a proxy for both technical complexity and for military capability. Within the FYDP, the Army's

force structure is primarily defined at the division level. No detailed information was available concerning the equipment in each of the divisions. Because of this limitation, it was not possible to study the O&S costs for a given type of weapon system in the Army force structure programs. Information was available on trends in aggregate primary mission programs, such as general purpose forces, and on Army direct support programs.

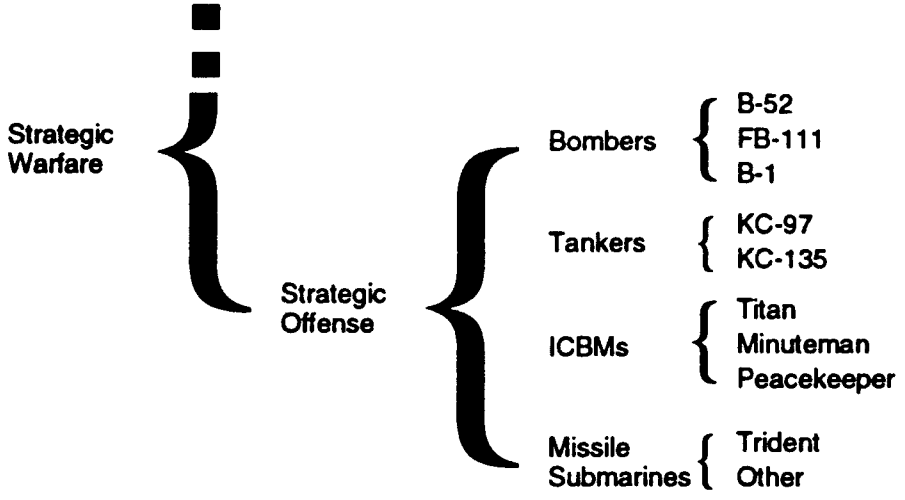

Figure II-2. Strategic Warfare Mission Area

To gain some insight into the trends in military manpower, we analyzed the military manpower data. For a selected group of aircraft systems, military manpower per weapon system was evaluated by determining the mean, standard deviation, and minimum and maximum number of personnel per system during the period from FY 1971 to FY 1990.

3. Data Issues and Adjustments

In our aggregate analyses, we defined O&S costs as the sum of operations and maintenance (O&M) and military personnel (MP) expenditures. O&S appropriations data were obtained from the historical FYDP data base. There are some difficulties in fully capturing the O&S costs associated with specific classes of forces. Some O&S costs associated with infrastructure program elements (PEs) are really tied to individual weapon systems. Examples are depot-level maintenance of a specific weapon. We tried to capture these in our case studies, but could not do so in the aggregate analyses of spending for different classes of defense missions. Similarly, some money in procurement accounts is really for operations and support. Examples are the procurement of training munitions,

spare parts, and reliability and maintainability modifications. We addressed this class of expenditures in our case studies, but could not do so in the aggregate analysis.

Within the FYDP, expenditures for O&M and MP are readily available across all the services. However, accounting practices used in generating MP totals have changed several times during the 20-year span of our study sample. The funding for retired pay and Civilian Health and Medical Program of the Uniformed Services (CHAMPUS) have moved between the Office of the Secretary of Defense (OSD) and the military services. This necessitates an adjustment to the MP funding across the FYDP to account for accounting changes in retired pay accrual and CHAMPUS.

The methodology also needed to consider the effect of O&M fuel-price adjustments resulting from the dramatic change in fuel prices, which distorts the deflators used in specific programs. Similarly, the Navy's adoption of a policy to fund depot-level repairables (DLRs) under the stock fund needed to be addressed. An adjustment for fuel prices is necessary because OSD uses a single O&M deflator for all types of O&M accounts, including primary mission programs that consume large amounts of fuel (aircraft and non-nuclear ships) and other programs that consume significantly less fuel (central personnel and administration). An adjustment is therefore required to more accurately represent the fuel component in the O&M costs of mission programs. Both the fuel-price adjustment and Navy DLRs are addressed in the statistical methodologies. To accommodate the fuel distortion to the O&M costs, we often used the fuel deflator as an independent variable. In the case of the Navy depot-level repairables, a dummy variable was inserted starting in FY 1981 for ships and in FY 1981 for aircraft.

B. CASE STUDIES

This section reviews the approach used for the case studies. . . states the hypotheses tested, the source of data, and the weapon systems studied.

Our third research question—Do O&S costs grow for weapons systems over time?—has two components: (1) What happens to O&S costs as a weapon system progresses through development? and (2) What happens between succeeding series of systems?

We began by posing two hypotheses. The first hypothesis was that the estimates of O&S costs grow as weapon systems progress through the acquisition process from RDT&E to production. The second hypothesis was that more complex, newer aircraft will have higher O&S costs than the systems they are to replace. These hypotheses were

derived from a priori beliefs about what occurs in the acquisition process and from conventional wisdom as to the relative O&S costs of weapon systems that have entered the inventory from the mid- to late 1970s through the 1980s.

The OSD Cost Analysis Improvement Group (CAIG) provided access to its files on independent cost estimates, especially those concerning the F-15, F-16, and F/A-18 programs. Additional program files were also reviewed. Although we examined the cost histories of the F-16, F-15, and F/A-18 in detail, the information in the CAIG files on other programs was insufficient to support a broader based analyses. For the Air Force, O&S cost data were derived from the 1990 version of the Cost-Oriented Resource Estimating (CORE) model [2]. In the case of the Navy, the information was obtained from the OSD CAIG and is based on the FY 1991 Amended Budget Estimate Submission.

Three comparisons were performed in the case studies. For the Air Force, the F-16 and the F-15 were each compared to the F-4. For the Navy, the F/A-18 was compared to the A-7.

III. ANALYSIS OF THE RELATIONSHIP BETWEEN AGGREGATE O&S COSTS AND DoD PROGRAMS

In the aggregate analysis of the relationship between O&S cost trends, the initial focus is on top-level trends for O&S spending, followed by a more detailed review of primary mission and direct support programs.

A. DoD O&S TRENDS

Historical FYDP data, as portrayed in Figure III-1, show that O&S expenditures have totaled roughly 60 percent of the overall defense budget. These expenditures reached a high of 66 percent in 1975 and a low of 53 percent in 1984 and 1985. In constant FY 1992 dollars, total DoD O&S costs have increased 8 percent from about $158 billion in FY 1971 to $170 billion in FY 1990. Most of the increase in O&S spending occurred between FY 1980 and FY 1985 as both the total DoD program and total O&S expenditures increased. As a percentage of total DoD expenditures, O&S spending has declined from 62 percent in FY 1971 to 58 percent in FY 1990.

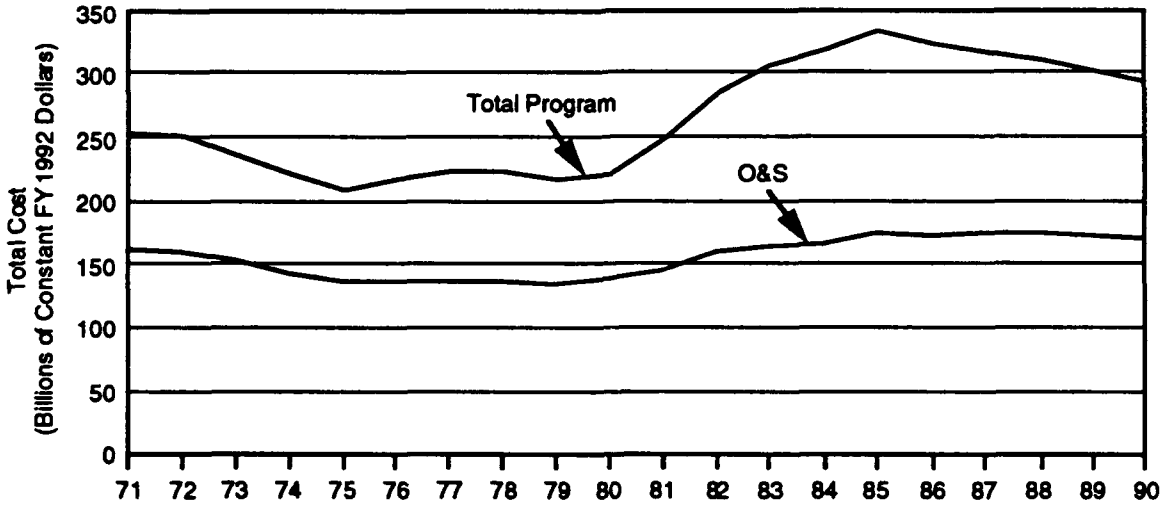

Figure III-1. Comparison of Total DoD Costs to Total O&S Costs, FY 1971–90

This does not seem to indicate untoward growth in O&S costs, but remember that many categories of force structure are substantially smaller today than they were in the 1970s. During this period of reductions in force structure O&S spending rose 8 percent.

The O&S spending patterns of the defense mission programs are portrayed in Figure III-2. The two places where aggregate O&S expenditures increased are force structure, or primary mission programs, and direct support programs. O&S spending on primary mission programs increased 18 percent from $44 billion in FY 1971 to $53 billion in FY 1990. O&S spending on direct support programs increased 80 percent from $12 billion to $18 billion over the same period. A reduction in O&S spending from $9 billion to $6 billion was experienced in other defense mission programs. The primary mission and direct support programs are examined in detail in subsections B and C so that we may begin to understand more about what has driven the increases in O&S expenditures.

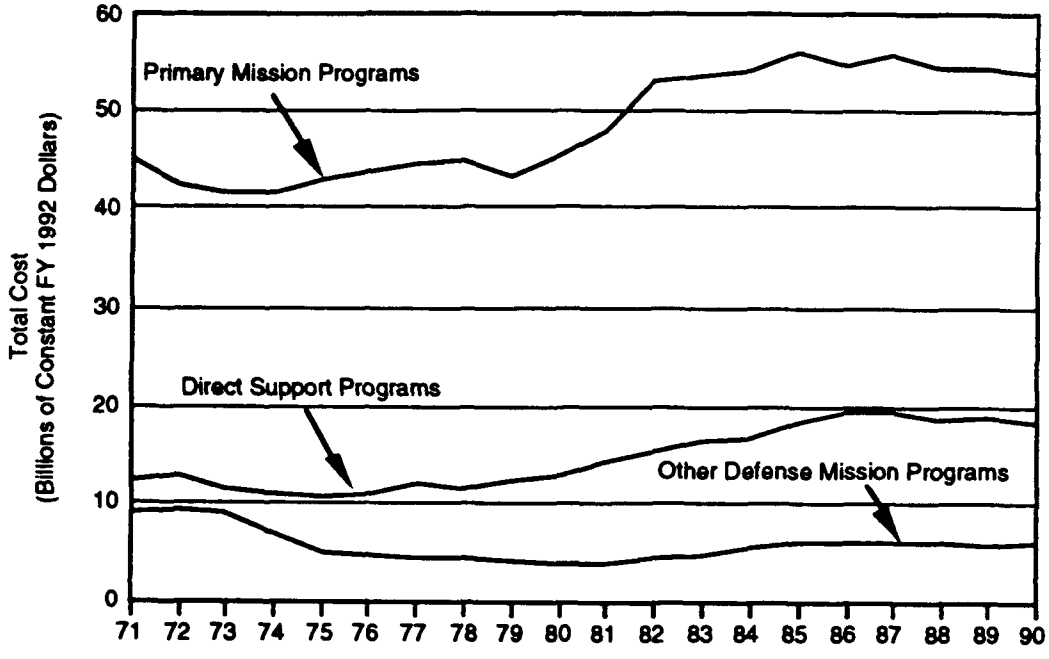

Figure III-2. O&S Costs for Defense Mission Programs, FY 1971–90

The relationship between O&S spending for infrastructure programs and defense mission programs is portrayed in Figure III-3. O&S spending on DoD infrastructure in FY 1971 was essentially the same as that in FY 1990, about $96 billion. Between FY 1974 and FY 1990, infrastructure O&S spending appears to be closely related to O&S spending in defense mission programs. The infrastructure programs were not addressed in detail in this study because they were not an overall source of cost growth.

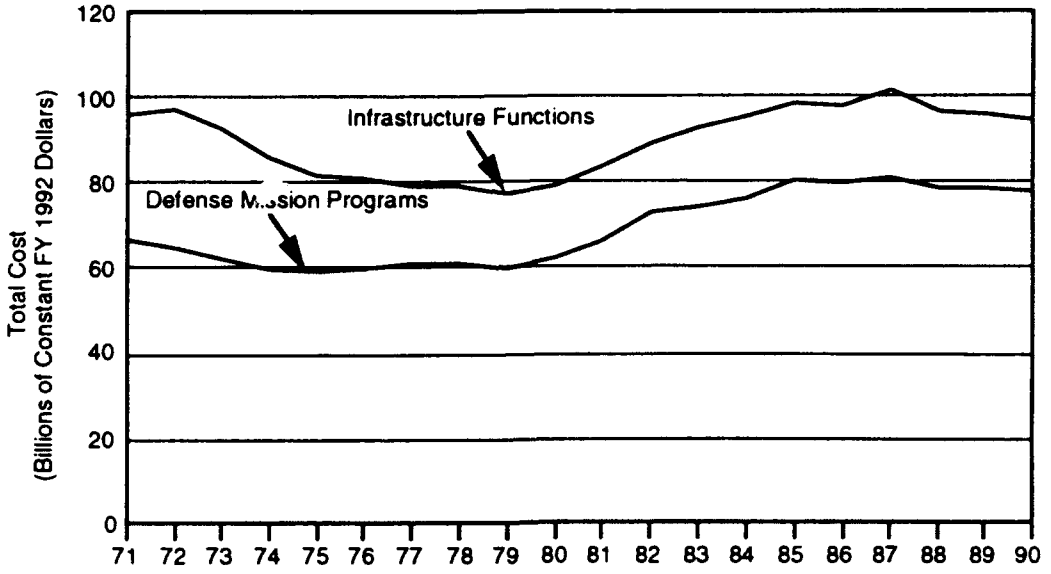

Figure III-3. Comparison of O&S Costs for Defense Mission Programs With Infrastructure Functions

B. PRIMARY MISSION PROGRAMS

This review of primary mission programs includes assessments of trends in O&S costs and military manpower levels. Selected primary mission programs in the Air Force, Navy, and Marine Corps are also reviewed.

1. Air Force

Based on the information developed in our analyses, the major results from our evaluation of Air Force primary mission program and operating and support costs are fourfold: (1) O&S expenditures per unit of force structure have been increasing for every class of weapon system examined with the exception of tactical airlift aircraft, (2) the retirement of older aircraft and their replacement with fewer, more capable, more costly aircraft is increasing capital asset value, (3) O&S expenditures are growing at a slower rate than the capital asset value of the aircraft inventory, and (4) small savings in military manpower are being experienced as new aircraft are introduced into the inventory.

The primary measure of force structure in the Air Force is its inventory of various types of aircraft. We separated this inventory by aircraft sub-mission and class. The five categories and the aircraft types and models analyzed were:

- Strategic Bombers—B-52, FB-111, and B-1;
- Strategic Tankers—KC-97 and KC-135;

- Strategic Airlift—C-5, C-141, KC-10A, C-97, and C-124;
- Tactical Aircraft—F-4, F-15A/B/C, F-15E, F-100, F-102, F-104, F-105, F-117, F-16A/B/C/D, F-111A/D/E/F, A-37, A-7, and A-10; and
- Tactical Airlift—C-130, C-7, and C-123.

a. O&S Costs

The study of O&S costs for these five aircraft categories revolves around the formulation of various regression models. The purpose of the models was to search for a time trend relationship. The use of the natural logarithm allows us to generate a relationship that yields coefficients that can be interpreted as yearly rates of change. The same approach was used to assess trends in capital asset value (CA), force structure (FS), O&S costs per unit of force structure (OS/FS), the average capital asset value per unit of force structure (CA/FS), and O&S costs per unit of capital asset value (OS/CA).

The regression models are as follows:

$$\ln O\&S = f(TM, FR),$$

$$\ln CA = f(TM, FR), \text{ and}$$

$$\ln FS = f(TM, FR),$$

where

O&S = operating and support costs,

CA = total capital asset value,

FS = total force structure (actual number of aircraft),

FR = fuel ratio, and

TM = time (dummy variable).

Total capital asset value (CA) represents the summation of the "fly away" cost at the 100th production unit times the number of aircraft for each type of aircraft in that category in FY 1992 constant dollars. This variable also serves as a measure of system technological advancement and as a rough measure of military capability. The logic behind using CA as a measure of technology advancement is that modern weapon systems are more expensive because they incorporate advanced technologies that allow more capable, higher-reliability designs. The logic behind treating CA as an indicator of capability is that, in an era of advancing technology, defense capability should rise more than CA because spending

money on new technology means that DoD thinks it can get more for its money than it could have by buying or using old technology.

The independent variable FR adjusts for the major differences in the price escalation factors for fuel and the other O&M commodities. If a fuel-ratio adjustment is not considered, significant errors can arise when using composite O&M deflators to calculate constant dollars for mission programs.

The results generated from using these models are presented in Table III-1. Several important observations can be made from the data. First, with the exception of tactical airlift aircraft, every category of aircraft has experienced a yearly increase in O&S costs per unit of force structure. This is not to say that every model of aircraft is driving up O&S costs, but that on the average there is a yearly net increase in O&S expenses per unit of force structure. When evaluating aggregate O&S costs, we found that three system types exhibited a decrease in O&S expenditures, strategic bombers, strategic tankers, and tactical airlift aircraft, but in all three cases force structure also declined. For strategic bombers and tankers this offset increases OS/FS.

Table III-1. Air Force Regression Results

	Percentage Change Per Year					
Aircraft Type	OS	FS	CA	OS/FS	CA/FS	OS/CA
Strategic Bombers	-1.38%	-2.46%	2.48%	1.08%	4.94%	-3.86%
Strategic Tankers	-0.21%	-0.88%	0.41%	0.68%	1.29%	-0.61%
Strategic Airlift	1.48%	0.78%	1.88%	0.70%	1.10%	-0.41%
Tactical Aircraft	2.00%	0.90%	4.00%	1.10%	3.10%	-2.00%
Tactical Airlift	-2.07%	-1.43%	NA	-0.64%	NA	NA

Note: NA means data were not available.

The decreases in total O&S expenditures (OS) for strategic bombers, strategic tankers, and tactical airlift aircraft are due to the reduction of the inventory of systems in these categories across the FYDP. B-52s and FB-111s were deactivated as the B-1 bombers entered active service, resulting in the total size of the bomber force being reduced at the rate of approximately 2.5 percent per year. The average O&S cost to operate a single bomber in the force structure (OS/FS) has been increasing at the rate of about 1 percent per year. The rate of reduction of the inventory (FS) for the strategic tankers is about 0.9 percent per year, while the average costs to operate a single tanker has been increasing at a rate of about 0.7 percent per year. The inventory of tactical airlift aircraft has been decreasing at a rate slightly less than 1.5 percent per year, and the O&S cost per tactical airlift aircraft has been decreasing at the rate of 0.64 percent per year.

The rate of growth in the ratio of CA/FS measures the degree to which the aircraft inventory is being modernized with aircraft of higher capital asset value over the course of the 20 years. An assessment of capital asset value for the tactical airlift aircraft was not available because of the lack of production cost data on C-123 and C-124. The capital asset value per unit of force structure is increasing at rates of about 1 percent per year for strategic airlift aircraft and strategic tankers, 3 percent for tactical aircraft, and 5 percent for bombers. The fact that all four of the aircraft categories with capital asset data exhibited a negative OS/CA value supports the basic hypothesis that O&S cost per dollar of aircraft production costs is declining. If we accept the notion that capital asset value is a good proxy for defense capability, then it takes less O&S spending now to achieve a given level of capability than was the case in the past.

b. Military Manpower

A major objective of weapon system acquisition programs within the Air Force has been to improve the reliability and maintainability of new weapon systems. An expected benefit from the introduction of more reliable and maintainable systems is lower maintenance manpower levels. For aircraft systems, maintenance manpower is the dominant component of the total manpower required to operate and support the system. The FYDP manpower data supports the basic belief that the manpower levels for new aircraft are consistently lower than for preceding weapon systems. However, the phasing in and out of weapon systems does affect the data, and the dispersion about the average manpower per unit provides insight into the changing manpower levels across the life of a weapon system. Military manpower levels for strategic bomber and tactical fighter and attack aircraft are the primary focus of the review.

Strategic bombers have experienced a reduction in military manpower per aircraft. Figure III-4 presents the mean, maximum, and minimum manpower levels for specific types of aircraft during the period and shows the standard deviation above and below the mean. The B-52 has experienced manpower levels that average about 72 personnel per aircraft. The FB-111 has averaged about 50 personnel per aircraft. The B-1 data are preliminary but show an average of 64 personnel per aircraft.

The tactical fighter and attack aircraft have also experienced a small reduction in manpower levels per aircraft. As presented in Figure III-5, the F-4 experienced an average of 31 personnel per aircraft compared to 29 for the F-15 and 28 for the F-16, the two aircraft that replaced the F-4. The A-7 experienced an average of about 24 personnel per aircraft compared to 25 for the A-10. The F-111 experienced an average of 35 personnel

per aircraft compared to 32 for the F-15E. We limited our analysis to those tactical aircraft shown in the figure.

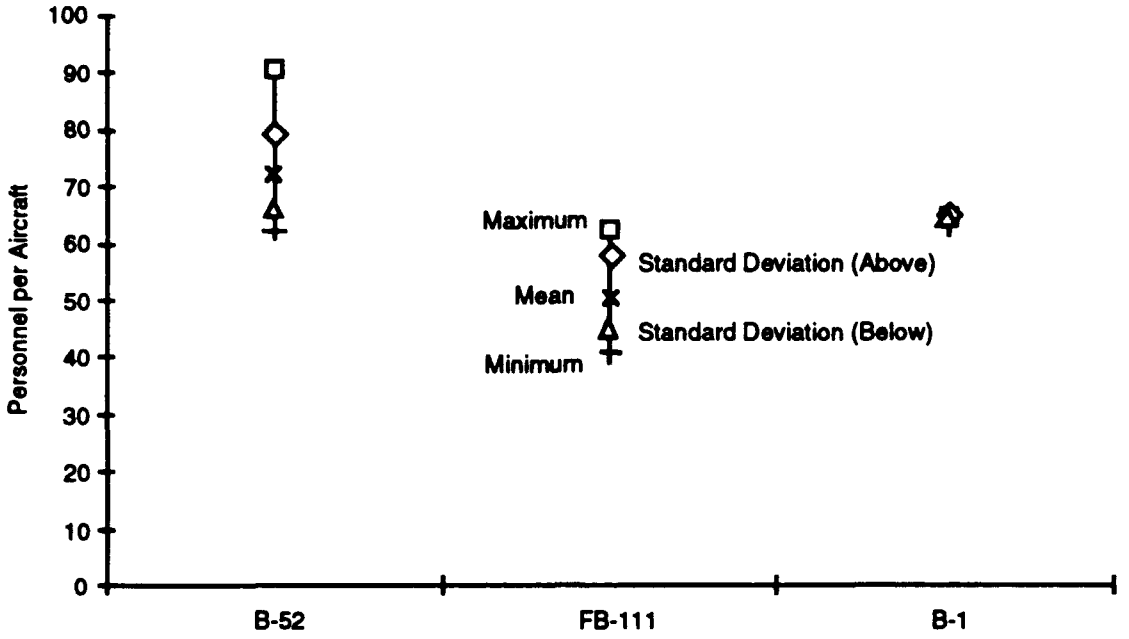

Figure III-4. Military Personnel Per Aircraft for Air Force Strategic Bombers, FY 1971–91

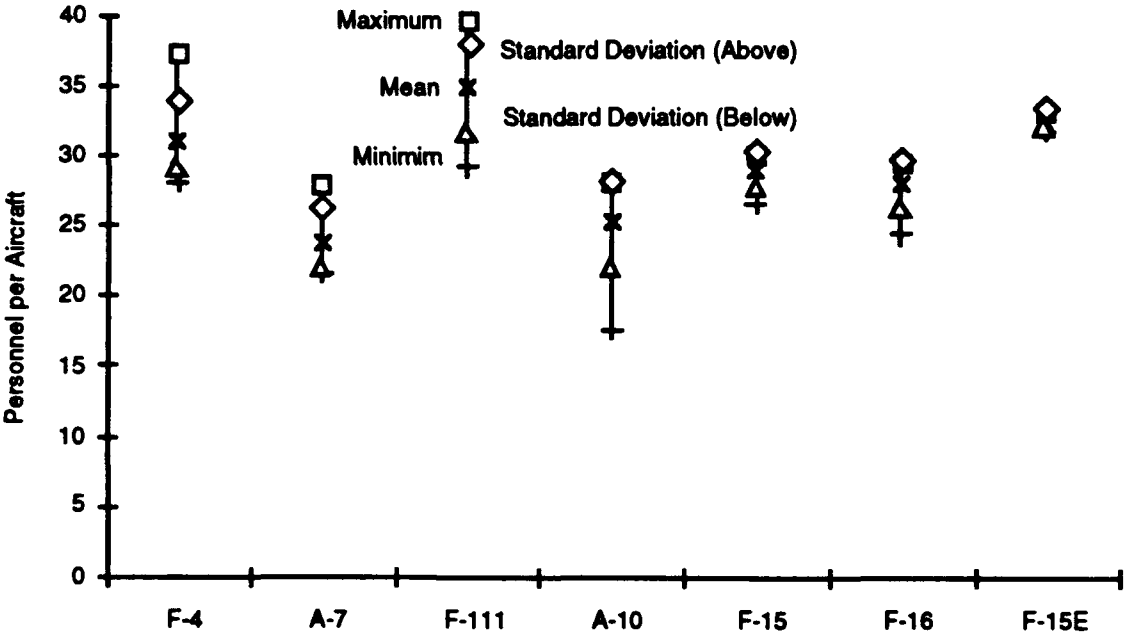

Figure III-5. Military Personnel Per Aircraft for Selected Air Force Tactical Aircraft, FY 1971–91

2. Navy

The O&S cost to operate the Navy force structure is reviewed for strategic forces (nuclear ballistic missile submarine fleet), and general-purpose forces (tactical aircraft, carriers, and surface combatants)

a. Strategic Systems

Between FY 1971 and FY 1990, the size of the nuclear ballistic missile submarine (SSBN) fleet was reduced from 41 SSBNs to 34, a reduction of 17 percent. The most significant change in the SSBN force began with the introduction of the Ohio class (SSBN 726) submarine in 1982. The Ohio class is capable of carrying 24 Trident missiles compared with 16 missiles for the Poseidon submarine, and the price of one SSBN 726 is roughly twice that of other SSBNs. It is important to note that Service Life Extension Program (SLEP) is funded from O&M accounts. Historically, these programs have caused substantial deviations in naval O&M accounts.

The regression equations for the Navy's strategic submarine fleet were slightly different from the aircraft regression models used for the Air Force. The equations used are as follows:

$$\ln O\&S = f(TM, DLR),$$

$$\ln O\&S = f(CA, DLR), \text{ and}$$

$$\ln O\&S = f(FS, DLR),$$

where

O&S = operating and support costs,

CA = total capital asset value,

FS = total force structure (number of systems),

TM = time (dummy variable), and

DLR = depot-level repairables (dummy variable).

The fuel-price adjustment was not necessary because all of the submarines in the Navy's SSBN fleet operate on nuclear power. The new variable represents the effects of changes in how the Navy funds its DLR program. The results of the regression analysis are presented in Table III-2. This analysis indicates that SSBN O&S expenditures have grown by 1.08 percent per year. However, fleet force levels demonstrated a 1.12 percent yearly decline. Thus, there has been a net increase in O&S cost of 2.2 percent per year per

submarine. The overall capital asset value of the fleet experienced a decrease of 0.43 percent per year. The ratio of OS/CA has also exhibited an increase in O&S expenditures of 1.5 percent per year. Unlike the case in the Air Force, the cost of supporting SSBNs rose more rapidly than the cost of buying them.

Table III-2. Navy Regression Results: Strategic Submarines

	Percentage Change Per Year					
System Type	OS	FS	CA	OS/FS	CA/FS	OS/CA
SSBN	1.08%	-1.12%	-0.43%	2.20%	0.70%	1.51%

b. General-Purpose Systems

For Navy general-purpose systems, tactical aircraft and the surface combatant programs were examined. The tactical aircraft category encompasses all the mission-coded tactical combat aircraft, stationed at sea or on land, in the Navy's inventory. Surface combatants can be broken down into two sub-categories: (1) aircraft carriers and (2) cruisers, destroyers, and frigates.

(1) Tactical Aircraft. We assessed Navy tactical aircraft using a similar methodology to that applied to strategic submarines and Air Force aircraft. As in the case of the Air Force aircraft, we added a variable to adjust for fuel pricing to both of these subcategories and reviewed military manpower levels. The Navy aircraft included in the analysis were:

- Fighter Aircraft: F-4, F-4J, F-4N, F-8J, F-14+, F-14D, and F/A-18; and
- Attack Aircraft: A-4F, A-6, A-6E, A-7A, A-7B, A-7C, A-7E, and KA-6A.

The results of the regression analysis are found in Table III-3. The Navy's tactical aircraft fleet experienced an annual increase in total O&S costs of 1.8 percent per year, while the force structure inventory was decreased at a yearly rate of 0.35 percent. The capital asset value of the force increased by 7.42 percent per year and the O&S cost per dollar of capital asset value decreased at 5.62 percent per year. The large increase in the capital asset value of the aircraft inventory results from the retirement and replacement of older aircraft (A-4, F-4, and F-8) with the more expensive and advanced A-6, F-14, and F/A-18. The negative value for the ratio of OS/CA shows that the Navy's trends in O&S costs are similar to the Air Force's.

The results, too, are similar: O&S costs rose, costs per unit of force structure rose, but the cost of supporting a fleet of aircraft of a given value fell dramatically.

Table III-3. Navy Regression Results: Tactical Aircraft

	Percentage Change Per Year					
System Type	OS	FS	CA	OS/FS	CA/FS	OS/CA
Tactical Aircraft	1.80%	-0.35%	7.42%	2.15%	7.77%	-5.62%

Like the Air Force, the Navy has placed emphasis during the acquisition of the F/A-18 on improving reliability and maintainability. A benefit resulting from this effort should be lower maintenance manpower for the system. As presented in Figure III-6, the data reviewed in the FYDP indicate a slight reduction in military manpower levels for the F/A-18. The F/A-18 replaced the A-7 and F-4 in the Navy tactical aircraft inventory. The F-4 experienced a mean of 28 personnel per aircraft, the A-7, a mean of 23 personnel per aircraft, and the F/A-18, a mean of 25. The mean number of personnel per aircraft for the F-14 was 28, the same as for the F-4, and the A-6 experienced a mean of about 24 personnel per aircraft.

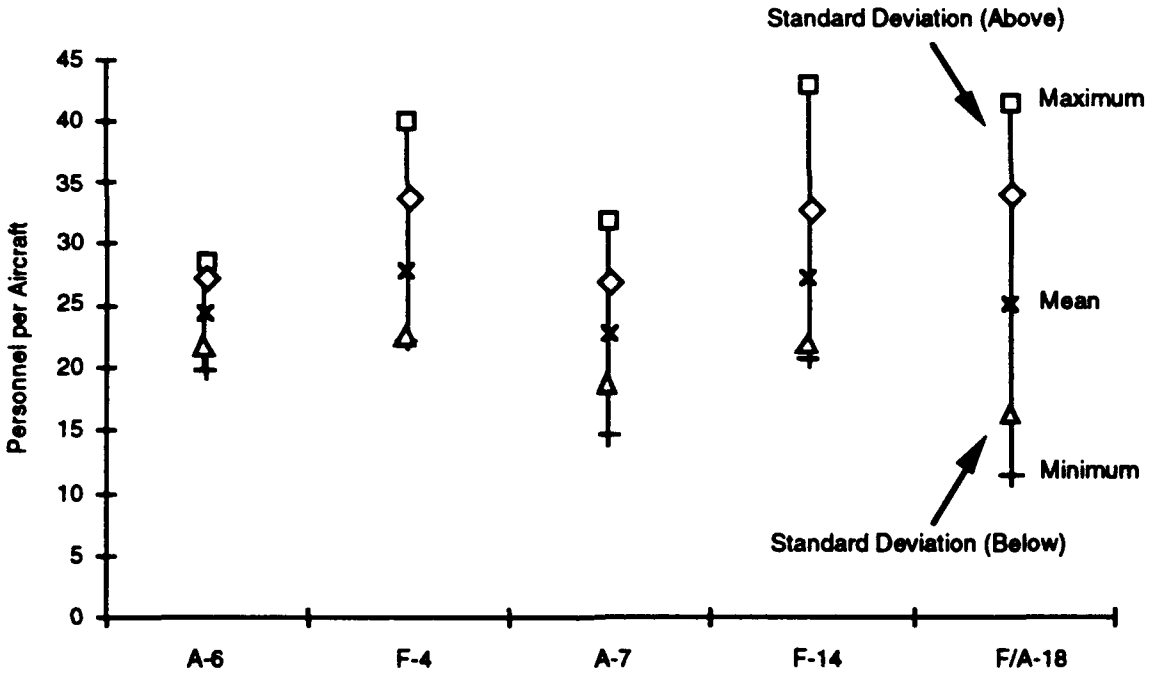

Figure III-6. Military Personnel Per Aircraft for Navy Tactical Aircraft, FY 1971–91

(2) Surface Combatants. Aircraft carriers are the first component of the surface combatant category we will examine. This group of ships has displayed a high level of overall O&S growth. From 1971 to 1990, total O&S costs grew by 43.6 percent, resulting in an annual growth rate of 2.9 percent. However, the number of ships varied by only one

or two ships from year to year, resulting in a small reduction in the inventory over the 20-year period. An examination of the force mix revealed that the number of nuclear-powered carriers has grown from 7 percent in 1971 to 43 percent in 1990. This growth reduces the effects of petroleum, oil, and lubricants (POL) usage and prices on carrier operations. As reflected in Table III-4, the O&S cost per aircraft carrier is growing at an annual rate of 3.6 percent, and the O&S cost per dollar of capital asset value is growing at the rate of 2.4 percent per year.

Table III-4. Navy Regression Results: Surface Combatants

	Percentage Change Per Year					
System Type	OS	FS	CA	OS/FS	CA/FS	OS/CA
Aircraft Carriers	2.92%	-0.63%	0.49%	3.55%	1.12%	2.43%
Cruisers, Destroyers, and Frigates	2.71%	-1.72%	NA	4.43%	NA	NA

Note: NA means data were not available.

The second component of surface combatants is the combination of all cruisers, destroyers, and frigates. This combination was necessary for two reasons. The first is that the FYDP does not link O&S expenditures or personnel to individual ships, just to ship classes (e.g., frigates, destroyers, etc.). Secondly, the Navy redesignated several ships during the mid-1970s, causing changes in force structure accounting.

The results of our analysis of cruisers, destroyers, and frigates, as reflected in Table III-4, show that the force structure has been experiencing an overall 1.7 percent yearly decline. The total funding consumed by 256 ships in 1971 was roughly $2.8 billion. By 1990 the force structure level reached 200 ships but consumed $4.1 billion. This totals a 46-percent increase over 20 years. This would appear to be a large increase in O&S costs. A complete set of CA values were not available for Navy ships that were in the inventory in the early 1970s, and for that reason, CA was not included in the regressions. However, the Navy has replaced the vast majority of its surface ships since the early 1970s, and these ships are much more expensive, complex, and capable. The implementation of the Navy's depot-level repairables program has also caused O&S expenditures to be inflated in the more recent years, but this was addressed by the DLR dummy variable in our equations.

In summary, the Navy is experiencing the same type of O&S costs trends as the Air Force concerning their fleet of tactical aircraft. The total O&S cost for tactical aircraft is increasing while the cost per dollar of the capital assets is decreasing. The Navy is experiencing a slight reduction in manpower per aircraft. However, the Navy's strategic

missile submarine and aircraft carrier fleets are experiencing O&S cost growth in excess of growth in capital asset value.

3. Marine Corps

The analyses of the Marine Corps's O&S expenditures revolve around its tactical fighter/attack aircraft. Marine aircraft data were used in regression equations similar to those for the Navy. As indicated in Table III-5, the results show an overall increase in O&S costs. However, the force structure levels also showed growth over the sample period. Annual increases in force structure were on the order of 2.14 percent, while O&S costs increased at a rate of 4.09 percent per year. These increases caused the 1.95-percent increase per year in the ratio of OS/FS. The CA value of the fleet is increasing at 5.06 percent per year. The F/A-18 and the AV-8B entered the Marine Corps inventory in large numbers to replace older, less expensive, and less capable aircraft such as the F-4 and the A-4. The ratio of OS/CA resulted in a -0.97 percent yearly rate of change and indicates that the Marine Corps is spending less O&S funds per dollar of aircraft production cost. We saw this same pattern for Air Force and Navy aircraft.

Table III-5. Marine Corps Regression Results: Tactical Aircraft

	Percentage Change Per Year					
System Type	OS	FS	CA	OS/FS	CA/FS	OS/CA
Tactical Aircraft	4.09%	2.14%	5.06%	1.95%	2.93%	-0.97%

C. DIRECT SUPPORT PROGRAMS

Direct support programs experienced a significant growth in O&S expenditures during FY 1971–91. These programs are responsible for providing direct support to the primary mission programs and include war reserve material, tactical missile procurement, mission-unique communications, and decentralized training and JCS exercises. O&S expenditures for direct support programs averaged $11 billion during FY 1971–80 and increased to an average of $17 billion during FY 1981–91. Direct support programs for each of the military services are reviewed in the following subsections.

1. Army

Table III-6 shows the average Army O&S expenditures for direct support programs during FY 1971–80 compared with the average expenditures for FY 1981–91. The Army experienced a $1 billion increase in the average between those two periods. The dominant

source of the increase is in training and JCS exercises, which experienced growth of $1 billion.

Table III-6. O&S Expenditures for Army Direct Support Programs

Program	Billions of FY 1992 Constant Dollars	
	FY 71–80 Average	FY 81–91 Average
Command, Control, and Communications	$0.1	$0.3
Logistics	$0.6	$0.7
Training and JCS Exercises	$1.0	$2.0
Other	$0.4	$0.2
Total Army	$2.2	$3.2

2. Navy

In Table III-7, the average Navy O&S expenditures for direct support programs during FY 1971–80 are compared with the average expenditures for FY 1981–91. The Navy experienced a $3.5 billion increase in the average between those two periods. The sources of the increase are in support ships ($700 million); training, exercises, and combat development ($500 million); intermediate maintenance activities ($500 million); and logistics support ($500 million).

Table III-7. O&S Expenditures for Navy Direct Support Programs

Program	Billions of FY 1992 Constant Dollars	
	FY 1971–80 Average	FY 1981–91 Average
Support Ships	$2.7	$3.4
Support Aircraft	$0.4	$0.5
Training, Exercises, and Combat Development	$0.7	$1.2
Weather, Mapping, and Oceanography	$0.3	$0.3
Command, Control, and Communications	$0.1	$0.3
Combat Support	$0.3	$0.3
Intermediate Maintenance Activities	$0.1	$0.6
Logistics Support	$0.1	$0.6
Other	$0.2	$0.2
Total Navy	$4.9	$7.4

3. Marine Corps

In Table III-8, the average Marine Corps O&S expenditures for direct support programs during FY 1971–80 are compared with the average expenditures during FY 1981–91. The Marine Corps experienced a $200 million increase in the average between those two periods. The sources of the increase are training and JCS exercises ($100 million) and other ($100 million).

Table III-8. O&S Expenditures for Marine Corps Direct Support Programs

Program	Billions of FY 1992 Constant Dollars	
	FY 1971–80 Average	FY 1981–91 Average
Training and JCS Exercises	$0.1	$0.2
Support Aircraft	$0.1	$0.1
Command Control and Communications	$0.1	$0.1
Other	$0.0	$0.1
Total Marine Corps	$0.3	$0.5

4. Air Force

In Table III-9, the average Air Force O&S expenditures for direct support programs during FY 1971–80 is compared with the those during FY 1981–91. The Air Force experienced a $2.1 billion increase in the average between those two periods. The sources of the increase are airlift/aerial port activities ($400 million), communications ($200 million), command and control ($200 million), missiles, war reserve material (WRM), and drones ($300 million), training activities ($700 million), and other ($300 million).

Table III-9. O&S Expenditures for Air Force Direct Support Programs

Program	Billions of FY 1992 Constant Dollars	
	FY 1971–80 Average	FY 1981–91 Average
Airlift/Aerial Port Activities	$0.5	$0.9
Communications	$0.4	$0.6
Command and Control	$1.2	$1.4
Missiles, WRM, and Drones	$0.2	$0.5
Training Activities	$1.0	$1.7
Other	$0.2	$0.5
Weather Service Activities	$0.3	$0.3
Total Air Force	$3.8	$5.9

5. Summary

Increases in annual direct support O&S costs affected all the services. Spending between FY 1981 and FY 1991 exceeded the FY 1971 to FY 1980 average by amounts ranging from 45 percent to 67 percent. Training and JCS exercises played an important part in all the increases.

IV. O&S CASE STUDIES

This chapter reviews the results of the portion of the analysis involving case studies. Two issues were examined: (1) the growth of O&S cost estimates as weapon systems progress through the acquisition process from RDT&E to production and (2) changes in O&S cost for succeeding generations of aircraft. We hypothesized that O&S cost estimates rise as the acquisition process proceeds. The expected impact of generation changes is less clear. We expected that added complexity would increase O&S costs, but added attention to reliability and maintainability in design should reduce them. The primary focus of the study was on the F-16, F-15, and F/A-18 programs. Three cross-generation comparisons were performed in the case studies. For the Air Force, two comparisons were made, both the F-16 and the F-15 were compared with the F-4. For the Navy, the F/A-18 was compared with the A-7.

A. O&S COST GROWTH FOR WEAPON SYSTEMS IN ACQUISITION

The hypothesis that estimates of O&S costs grow as weapon systems progress through development and production was the first concept evaluated. The original objective of the case study was to review a large number of systems to gain information to accept or reject this hypothesis. However, limited O&S cost information on the majority of systems reviewed by the OSD CAIG constrained the number of systems reviewed to the F-16, F-15, and F/A-18. This small sample precludes drawing a definitive conclusion relative to the hypothesis; however, information for the F-16 and F-15 appears to support the hypothesis, while information on the F/A-18 does not support the hypothesis.

1. F-16

The information reviewed for the F-16 supported the hypothesis that O&S costs tend to grow as a system progresses through development to production. As presented in Figure IV-1, the O&S costs for a F-16A/B squadron of 24 aircraft with normalized flying hours increased by 31 percent from a full-scale development estimate in 1976 of approximately $40 million (FY 1991 constant dollars) to an estimate in the Air Force's FY 1990 SABLE model of $52 million. Although the cost element structures between the estimates are not the same, the costs were placed in consistent categories to allow

comparisons. When comparing the 1976 ICA and 1990 SABLE estimates, we found costs were underestimated for personnel pay, operations (fuel consumption), and procurement (spare parts) and depot maintenance (aircraft and component repair).

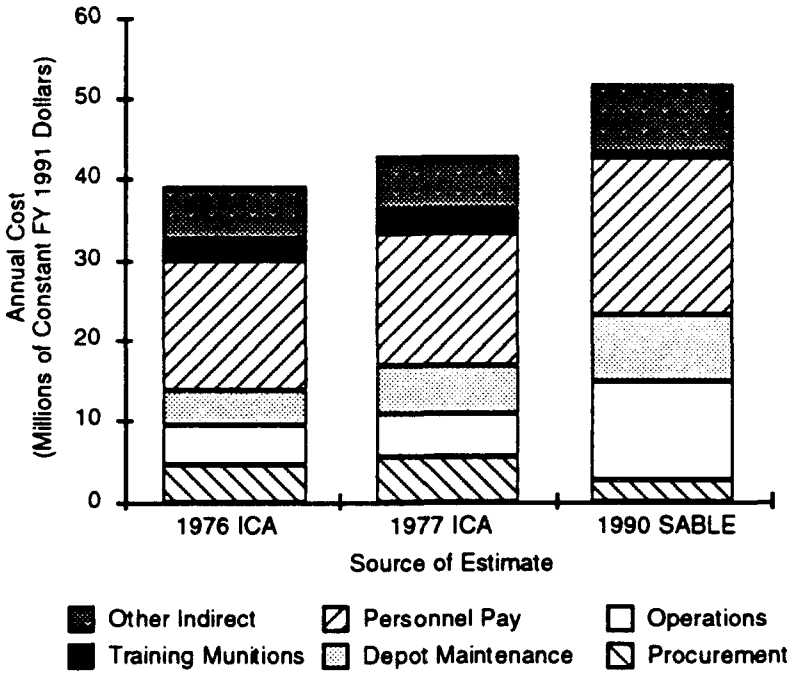

Figure IV-1. Annual O&S Cost Estimates for F-16A/B Squadrons

2. F-15

Results for the F-15 are similar to those for the F-16. As presented in Figure IV-2, the direct unit O&S costs for a F-15A/B squadron of 24 aircraft with 287 flying hours increased by roughly 67 percent from the system program office estimate in 1975 of approximately $42 million (FY 1991 constant dollars) to the current estimate of $69 million based on the Air Force's FY 1990 SABLE model. The OSD CAIG estimate was $52.3 million or roughly 33 percent below the FY 1990 SABLE estimate. Although the cost element structures between the estimates are not the same, the costs were placed in consistent categories to allow comparisons. When comparing the 1975 estimate to the 1990 estimate, we found that costs were underestimated for personnel pay, operations (fuel consumption), and depot maintenance (aircraft and component repair).

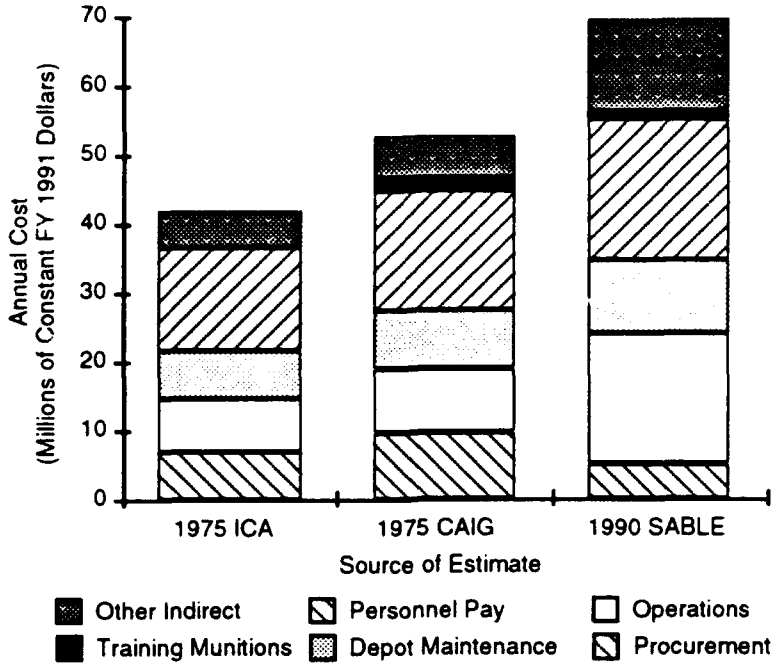

Figure IV-2. Annual O&S Cost Estimates for F-15A/B Squadrons

3. F/A-18

The information reviewed for the F/A-18 did not support the hypothesis that O&S costs grow as a system progresses through development to production. A 1975 estimate was higher than the current data on the F/A-18. Figure IV-3 presents the O&S costs for selected cost elements for an F/A-18A/B squadron of 12 aircraft with normalized flying hours. The O&S cost was essentially the same for a full-scale development estimate in 1975 of approximately $17.4 million (FY 1992 constant dollars) to a current estimate of $17.2 million. The Navy's FY 1991 amended budget estimate submission (ABES) is the source of the current estimate. Although the cost element structures between the estimates are not the same, the costs were placed in consistent categories to allow comparisons. When comparing the 1975 estimate to the FY 1991 ABES estimate, the areas where costs were different include mission personnel and spare parts, depot-level repairables, and consumables.

Also presented in the figure is the actual A-7E O&S costs as reported in the ABES. The data show that the F/A-18's O&S costs are higher than the A-7E's. The A-7E's O&S costs are about $14 millions in FY 1991 constant dollars or approximately 80 percent of the F/A-18's costs of about $17 million per squadron per year. O&S costs for the A-7E are lower than for the F/A-18 in the areas of fuel and spares, depot repair, and consumables.

The effects of providing a multirole fighter with added capability and complexity appear to have outweighed the emphasis given to reliability and maintainability in the design process.

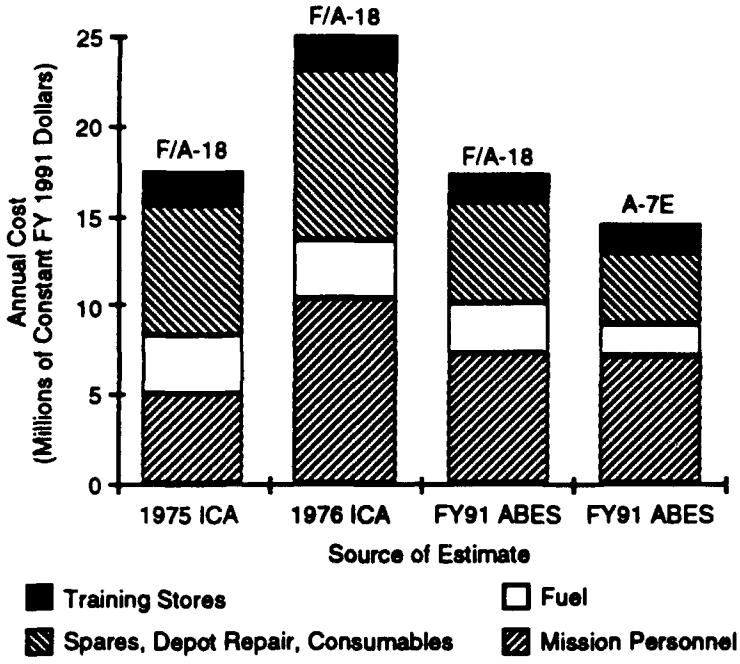

Figure IV-3. Annual O&S Cost Estimates for Navy Aircraft Squadrons

B. O&S COST COMPARISON OF THE F-15 AND F-16 TO THE F-4

Cost comparisons were made between the succeeding versions of Air Force air superiority fighters, F-4E and F-15A/B, and multirole fighters, F-4D and F-16A/B. The results of the comparisons are presented in Figure IV-4. These comparisons are for total annual O&S costs for squadrons with 24 aircraft and normalized flying hours.

The cost analyses show that O&S costs for the F-15 and F-16 are less than for the F-4. Both the F-4E and F-4D cost about $91 million per squadron in FY 1992 constant dollars. The F-15A/B costs about $69 million per squadron per year or roughly 30 percent less than the F-4E. O&S costs are reduced in about every cost element, especially fuel, personnel, and depot maintenance. An F-16A/B squadron costs about $50 million per year or roughly 45 percent less than the F-4D. As in the case of the F-15, the F-16 has lower O&S costs for fuel, personnel pay, and depot maintenance. In sum, despite the greater capability of the F-15 and F-16 relative to the F-4, it was possible to achieve lower O&S costs.

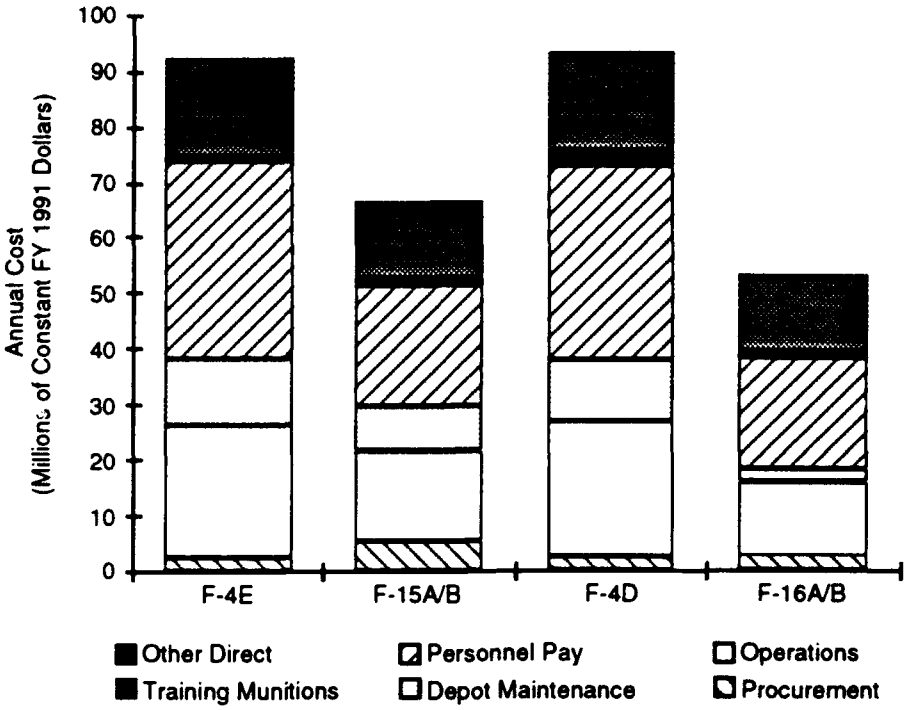

Figure IV-4. Annual O&S Cost Estimates for F-15, F-16, and F-4 Squadrons

V. SUMMARY

The purpose of this research was to improve the understanding of the ways in which O&S costs have changed over the last 20 years. The emphasis was on the relationships between operating and support (O&S) costs and the forces they support. Although the study was not intended to be comprehensive in the evaluation of these relationships, it provides information on general trends and probes selected O&S cost issues. To gain insight into the general trends, a broad-based investigation of historical O&S costs encompassing the dominant portion of the DoD program was accomplished. To probe O&S cost issues, the study progressed from this overview down to the individual services, the missions of the services, the weapon systems responsible for completion of these missions, and infrastructure programs that support these mission programs.

The report addresses three questions central to the study: Has O&S spending grown faster than the budget? If O&S spending has grown, what has contributed to the growth? and Do O&S costs grow for weapon systems over time (during acquisition and from one model to the next)?

To address these questions, a two-part study was performed. The first part investigated the relationship between forces and aggregate O&S costs for the period from FY 1971 to FY 1990. The second part probed down to the system level to address the question of whether or not O&S costs increase in specific weapon systems over time. A series of case studies on individual weapon systems was conducted to assess cost growth as the systems progress through development to production. The results of each of these studies are summarized in the sections that follow.

A. AGGREGATE O&S COSTS

For the study of aggregate O&S costs, the following questions were addressed: has O&S spending grown faster than the budget? and Has O&S spending grown faster that the forces they support? Our results indicate that in constant FY 1992 dollars total DoD O&S costs have increased from about $158 billion in FY 1971 to $170 billion in FY 1990. The primary source of growth in aggregate O&S expenditures are attributed to primary mission programs and direct support programs. Reductions in O&S costs were experienced in other defense mission programs, while defense infrastructure functions appear to have remained

unchanged. The results of our analyses of primary mission programs in the Air Force, Navy, and Marine Corps and direct support programs in the Army, Navy, Marine Corps, and Air Force are provided in the subsections that follow.

1. Primary Mission Programs

The major results from our analysis of Air Force primary mission programs were that: (1) total O&S costs for primary mission programs have experienced a slight reduction, (2) O&S expenditures per unit of force structure have been increasing for the majority of the classes of weapon systems with the exception of tactical airlift aircraft, (3) O&S expenditures are growing at a slower rate than the capital asset value of the aircraft inventory, and (4) military manpower has experienced a slight reduction as new aircraft are introduced into the inventory.

Across all categories of force structure, the Navy is experiencing increases in the O&S costs to operate its force structure. These range from an annual increase of 1.08 percent for strategic submarines to a 2.9 percent for aircraft carriers. The increases in O&S costs have been occurring even though the Navy force structure has been declining. The rate of decline varies from a low of -0.35 percent per year for tactical aircraft to -1.72 percent for surface combatants. The O&S cost per unit of force structure has also been increasing. The rate of increase has been roughly 2.2 percent for strategic submarines and tactical aircraft, 3.6 percent for aircraft carriers, and 4.4 percent for surface combatants. The O&S cost per dollar of capital asset value has been increasing for strategic submarines (1.5 percent), decreasing for tactical aircraft (-5.6 percent), and increasing for aircraft carriers (2.4 percent.) Military manpower to support Navy tactical aircraft reflects a slight reduction as new weapon systems are introduced into the inventory. In sum, the Navy force structure is becoming increasingly more costly to operate and support.

For tactical aircraft in the Marine Corps, the O&S costs have been increasing at the rate of about 4 percent per year. However, the force structure has also been increasing on the order of 2.1 percent per year, resulting in an annual O&S cost increase of 1.95 percent per unit of force structure. The O&S costs per dollar of capital asset value have been decreasing at about 1 percent per year.

2. Direct Support Programs

Direct support programs experienced a significant growth in O&S expenditures. These programs include war reserve material, tactical missiles, mission-unique communications, and decentralized training and JCS exercises. O&S expenditures for

direct support programs averaged $11 billion during FY 1971–80 and increased to an average of $17 billion during FY 1981–91.

The Army experienced a $1 billion increase in the average O&S expenditures for direct support programs between these two periods. The dominant source of the increase was training and JCS exercises.

The Navy experienced a $3.5 billion increase in the average direct support program O&S expenditures from $4.9 billion during FY 1971–80 to $7.4 billion during FY 1981–90. The sources of the increase were support ships; training, exercises, and combat development; intermediate maintenance activities; and logistics support.

The average Marine Corps O&S expenditures for direct support programs during FY 1971–80 compared to the average expenditures for FY 1981–91 increased $200 million. The sources of the increase were training and JCS exercises and other programs.

The average Air Force O&S expenditures for direct support programs for FY 1971–80 compared to the average expenditures for FY 1981–91 experienced an increase of $2.1 billion. The sources of the increase were airlift/aerial port activities; communications; command and control; missiles, WRM, and drones; training activities; and other programs.

B. CASE STUDIES

Two hypotheses were used as the basis for the case studies analyses. The first hypothesis was that the estimates of O&S costs grow as weapon systems progress through the acquisition process from RDT&E to production. The information reviewed for the F-16 and F-15 supported the hypothesis that O&S costs tend to grow as a system progresses through development to production. O&S costs for a F-16A/B squadron increased by 30 percent from a full-scale development estimate in 1976 of approximately $40 million (FY 1991 constant dollars) to an FY 1990 estimate of $52 million. The direct unit O&S costs for a F-15A/B squadron increased by roughly 64 percent from the system program office estimate in 1975 of approximately $42 million (FY 1991 constant dollars) to the current estimate of $69 million. The information reviewed for the F/A-18 did not support the hypothesis. The O&S cost was essentially the same for a full-scale development estimate in 1975 of approximately $17.4 million (FY 1991 constant dollars) compared to a current estimate $17.2 million.

The second hypothesis was that O&S costs for newer, more complex aircraft would be lower than the O&S costs of the aircraft they are to replace. Both the F-4E and the F-4D

cost about $91 million in FY 1992 constant dollars. The F-15A/B costs about $69 million per squadron and the F-16A/B squadron costs about $50 million per year. Therefore, in the case of the comparison between the F-4 and the F-15 and F-16, the second hypothesis was supported.

This was not the case for the comparison of the F/A-18 to the A-7. The O&S costs for the F/A-18 are greater than for the A-7. The A-7E costs about $14 million per squadron per year in FY 1991 constant dollars, which is approximately 80 percent of the F/A-18 costs of about $17 million. Therefore, in this case, the second hypothesis was rejected.

REFERENCES

REFERENCES

[1] Wilson, James L., Waynard C. Devers, Thomas P. Frazier, Matthew S. Goldberg, Stanley A. Horowitz, and John J. Kane. "Considerations in a Comprehensive Total Force Cost Estimate." Institute for Defense Analyses, Paper P-2613, November 1992.

[2] Department of the Air Force. "U.S. Air Force Cost and Planning Factors." Air Force Regulation 173-13.

ABBREVIATIONS

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ABES	amended budget estimate submission
CA	capital asset
CAIG	Cost Analysis Improvement Group
CHAMPUS	Civilian Health and Medical Program of the Uniformed Services
CORE	Cost-Oriented Resource Estimating
DLR	depot-level repairable
DoD	Department of Defense
FYDP	Future Years Defense Program
IDA	Institute for Defense Analyses
JCS	Joint Chiefs of Staff
MP	military personnel
O&M	operations and maintenance
O&S	operating and support
OSD	Office of the Secretary of Defense
PE	program element
POL	petroleum, oil, and lubricants
RDT&E	research, development, test and evaluation
SSBN	nuclear ballistic missile submarine
WRM	war reserve materials