Costs of Expanding and Modernizing the Navy's Carrier-Based Air Forces

A CBO Study
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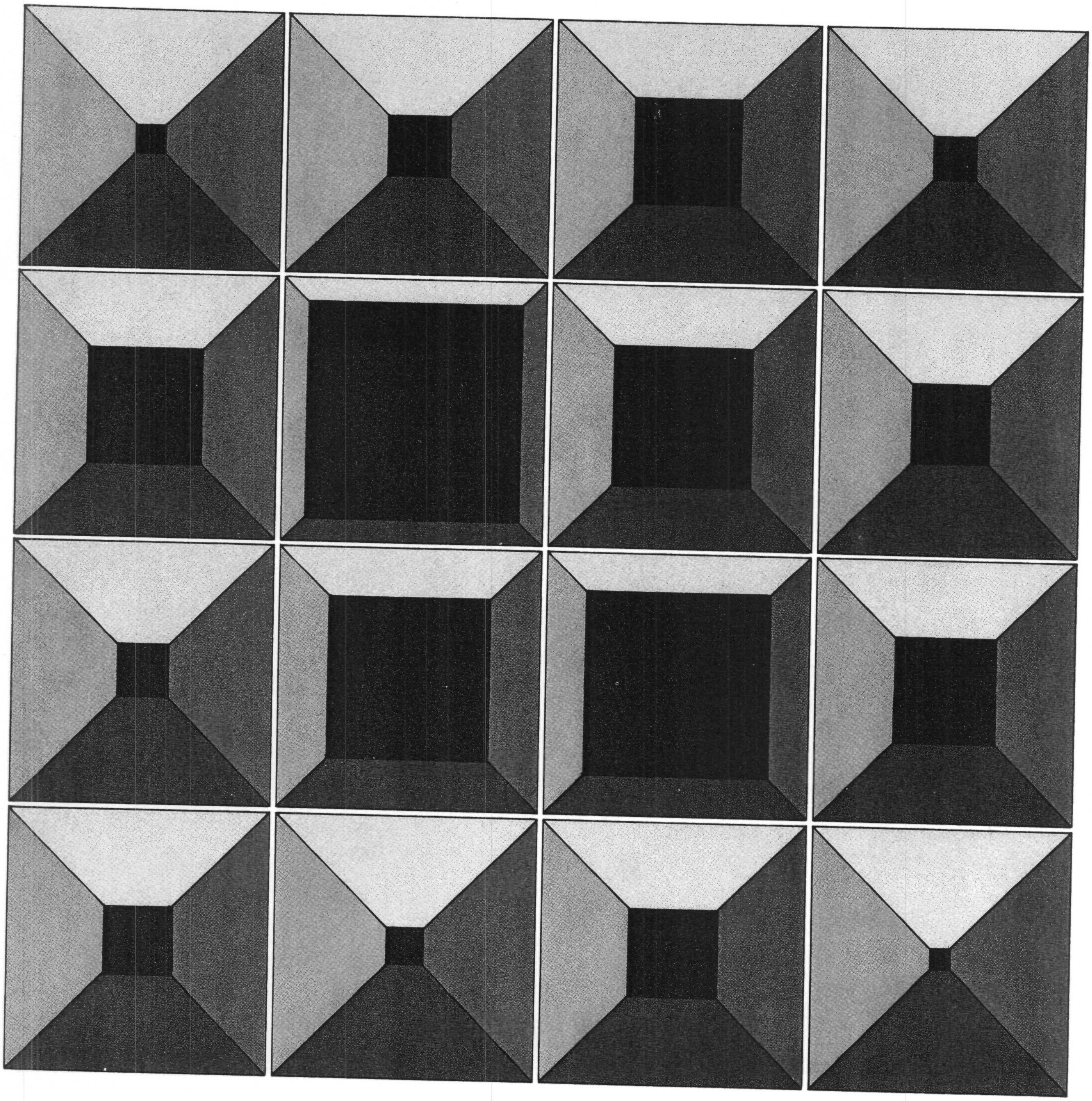
Congress of the United States
Congressional Budget Office



COSTS OF EXPANDING AND MODERNIZING THE NAVY'S CARRIER-BASED AIR FORCES

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PREFACE

The Administration's defense program includes a major expansion of the Navy. This program would involve substantial expenditures not only for additional ships but also for naval aircraft, both to establish new carrier-based air wings and to complete the modernization of the 12 existing wings.

This report, prepared at the request of the House Committee on Armed Services, estimates the cost of adding new Navy air wings and modernizing the Navy's fighter and attack forces. It also examines alternative approaches to Navy aircraft force modernization. A companion paper, Building a 600-Ship Navy: Costs, Timing, and Alternative Approaches, examines shipbuilding issues, while a forthcoming Congressional Budget Office (CBO) paper will address manpower concerns. In accordance with CBO's mandate to provide objective and impartial analysis, the paper offers no recommendations.

This study was prepared by Alan H. Shaw of CBO's National Security and International Affairs Division, under the general supervision of Robert F. Hale and John J. Hamre. Patrick Haar of CBO's Budget Analysis Division reviewed the cost estimates. Robert L. Vogel assisted in preparing the paper. Discussions with Peter T. Tarpgaard and Edward A. Swoboda of CBO were useful in preparing this paper. It was reviewed at various stages by Alfred B. Fitt of CBO and by Dr. John Transue. The cooperation of the U.S. Navy in providing data is gratefully acknowledged. The assistance of external reviewers and of the Navy implies no responsibility for the final product, which rests solely with CBO. Francis Pierce and Robert L. Faherty edited the manuscript; Janet Stafford prepared it for publication.

Alice M. Rivlin
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SUMMARY

To counter the growing threat of the Soviet navy, the Administration has announced its intention to reverse the long-term decline in the size of the U.S. Navy and otherwise improve Navy capabilities. It proposes to expand the U.S. fleet from the current 535 ships to roughly 600 and to increase the number of carrier-based air wings from 12 to 14. In addition to expanding, the Navy plans to modernize the existing carrier air forces, replacing 360 aircraft with more recent types, notably the F/A-18. This paper estimates the cost of the Navy's plan to expand and modernize its carrier air forces and examines alternatives to parts of that plan, while a companion Congressional Budget Office paper analyzes the shipbuilding issue.

BACKGROUND: CARRIER-BASED AIR FORCES

The Navy's general purpose forces are structured primarily around aircraft carrier battle groups. A carrier battle group consists of one or two carriers, escorting surface combatants (cruisers, destroyers, and frigates), and various logistics and support ships. Some aircraft on the carrier provide the ability to attack targets ashore and afloat at ranges up to more than 1,000 nautical miles, while other aircraft and the escorting combatants control the sea around the battle group, protecting it from surface ships, submarines, and aircraft.

The Navy currently has 14 carriers, not including one used solely for training. These range in size from two built at the end of World War II, which displace about 60,000 tons each, to four nuclear-powered carriers displacing about 90,000 tons at full load. One carrier is currently undergoing service life extension, a major overhaul lasting about two years, and is not counted as deployable. When the process is complete, that carrier will be followed by another, and so on. Thirteen carriers are currently deployable. There is one air wing for each deployable carrier except the Vinson, which was commissioned in 1982 and for which a wing has not yet been established.

A typical air wing consists of about 90 aircraft of different types: 34 attack aircraft, which are used to deliver bombs and

missiles against surface targets; 24 fighters, which protect the battle group against enemy aircraft and escort the attack aircraft; 16 antisubmarine warfare aircraft; and 16 other aircraft for early warning, reconnaissance, electronic warfare, in-flight refueling, and cargo delivery or utility work.

Attack Aircraft. At present, each air wing has one squadron of 10 A-6E medium-attack aircraft and two squadrons of 12 A-7E light-attack aircraft. The A-6E can carry more bombs farther than the A-7E can, under a greater range of weather conditions. It is also more costly than the A-7E, and larger; it carries a crew of two, while the A-7E is a single-seat aircraft.

Fighters. Each wing has two squadrons of 12 fighters. Currently, nine wings have F-14s while three still have the older F-4 aircraft. The F-14 is a variable-geometry, two-seat interceptor with a top speed in excess of Mach two. It was designed to carry the long-range Phoenix air-to-air missile, which gives it the unique capability to engage several enemy aircraft simultaneously at long range. It also carries shorter-range weapons. The F-4 is being phased out.

The F/A-18. The F/A-18 is a multimission aircraft that is being procured both as a light-attack aircraft and as a fighter. It is currently in production but has not yet entered the fleet except in a training squadron. It is a single-seat airplane with a top speed of about Mach 1.8. It is a major component of the Navy's modernization program, intended as a replacement for the A-7E. It has been the subject of much discussion in the Defense Department, the Congress, and the press, and its ultimate role in the fleet still remains somewhat unclear.

THE NAVY PLAN FOR EXPANSION AND MODERNIZATION

The Navy will establish one new air wing in 1983 for the carrier Vinson, which entered the fleet in 1982. This will require the creation of the squadrons in that wing and the procurement of enough aircraft to equip and support those squadrons. According to current plans, that air wing will have F-14 fighters and F/A-18 light-attack aircraft.

The Navy anticipates delivery of the carrier Roosevelt, currently under construction, in December 1986. Two other carriers, for which funding has been requested in fiscal year 1983, would be delivered in December 1989 and December 1991. Retirement of the two oldest carriers, the Coral Sea and the Midway, would result in a net increase of one carrier and the introduction of one additional air wing with the same composition as the wing being created for the Vinson.

Until 1981, the F-14 procurement program was to terminate in fiscal year 1983 with the completion of a sufficient inventory to maintain 18 squadrons of 12 F-14s each. The other 6 fighter squadrons were to be equipped with F/A-18s. The Navy now seeks to equip 10 more squadrons with F-14s--the 6 previously scheduled to receive F/A-18s and the 4 assigned to the two new wings.

The A-7E has been in the fleet since 1970, and will begin reaching the end of its service life in the mid-1980s. The shortfall in inventory that will occur as the A-7Es begin to be retired will have to be filled either by building more A-7Es or by replacing the A-7E as the Navy's light-attack aircraft. The Navy has decided to replace it with the F/A-18. In order to accomplish this, the Navy will have to buy enough F/A-18s to equip 28 squadrons, including the 4 assigned to the two new wings. This decision was based in part on the Navy's view that the A-7E, a subsonic aircraft with relatively sluggish performance, is becoming too vulnerable to Soviet fighters. Replacing it with the F/A-18, which has the aerodynamic performance of a fighter, would redress the problem in the Navy's view.

Furthermore, the fact that the F/A-18 can be flown as a fighter by loading it with air-to-air missiles rather than air-to-surface weapons imparts what the Navy views as valuable flexibility. F/A-18s can fly escort for other F/A-18s, freeing F-14s for fleet air defense, and F/A-18s can also be used to augment F-14s in fleet air defense.

COSTS OF THE NAVY'S MODERNIZATION AND EXPANSION PLAN

Long-Term Costs

The costs beyond 1982 of the Navy plan--that is, to add two new wings and to replace all the remaining F-4s with F-14s and the A-7Es with F/A-18s--will amount to $30 billion. (Except where noted all costs are in constant 1983 dollars.) This includes the cost of aircraft assigned to squadrons, of aircraft added to training squadrons and the repair pipeline, and of aircraft purchased in advance to replace peacetime losses (advance attrition aircraft) for 15 years.

Each new air wing will cost $5.6 billion, if all the required aircraft are procured. The production lines are currently closed, however, for both types of antisubmarine warfare (ASW) aircraft deployed in carrier air wings--the S-3 fixed-wing aircraft and the SH-3 helicopter. The $5.6 billion total includes reopening the S-3 line and replacing the SH-3 with the SH-60 helicopter. Were the Navy not to buy any more ASW aircraft, about $850 million would be saved, but the number of ASW aircraft deployed per carrier would have to be reduced both to accommodate the new carriers and to make up for peacetime attrition. Under these circumstances, ASW operations would eventually become impossible.

In addition to the procurement costs, each air wing would cost about $200 million per year to operate and support.

Ten squadrons of F-14s would cost $11.2 billion. This includes the four squadrons in the new wings and the six that are to replace the older F-4s.

Equipping 28 light-attack squadrons with F/A-18s would cost $13.9 billion, charging these aircraft at the average unit cost of the number remaining to be procured beyond 1982. That number might, however, be changed, with an accompanying change in average unit costs. The current F/A-18 program is expected to produce about twice as many aircraft as are needed to equip the carrier attack squadrons; the remaining aircraft are being procured for other purposes. Furthermore, since the list of applications for the F/A-18 has undergone extensive alteration since the current production goal of 1,366 was arrived at, it is possible that the goal will be revised in the near future. Finally, the Administration has already indicated that it will seek yearly production rates that are significantly different from those previously planned; this would also cause changes in unit costs.

Five-Year Costs

The costs of expansion and modernization will not all be incurred over the next five years. During that period, however, the Navy plans to procure 936 aircraft of types deployed on aircraft carriers at a total cost of $25.6 billion (see Summary Tables 1 and 2).

Some of these aircraft are not for expansion and modernization but to fill shortfalls in existing inventories, while others

SUMMARY TABLE 1. ADMINISTRATION REQUEST FOR CARRIER AIRCRAFT PROCUREMENT (By fiscal year)

Aircraft	1983	1984	1985	1986	1987
A-6E	8	8	12	12	12
F/A-18	84	96	108	132	132
F-14	24	30	30	30	30
E-2C a/	6	6	6	6	6
EA-6B b/	6	6	6	6	6
SH-60 c/	--	--	--	64	64

a/ Airborne early warning.

b/ Electronic warfare aircraft.

c/ Antisubmarine warfare helicopter.

are for the Marine Corps. The F/A-18 is being procured for several purposes. The costs shown in Summary Table 2 are thus the anticipated total expenditures on all carrier aircraft in 1983-1987, not just the costs of expansion and modernization.

ALTERNATIVE MODERNIZATION PLANS

Several alternative approaches could achieve the Navy's goal of equipping 10 fighter squadrons and 28 attack squadrons. These consist of using the F/A-18 as a lower-cost Navy fighter to complement the F-14 and modernizing the attack force with something other than the F/A-18. Since the F/A-18 figures in all of the alternatives, the following section describes it more fully.

The F/A-18

The high cost of the F-14/Phoenix system being procured in the 1970s led to the development of the F-18 as a less expensive complement. The F-18 does not carry the long-range Phoenix missile, although like the F-14 it carries short-range Sidewinder missiles and medium-range Sparrow air intercept missiles.

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SUMMARY TABLE 2. COSTS OF CARRIER AIRCRAFT PROCUREMENT (By fiscal year; in millions of 1983 dollars)

Aircraft	1983	1984	1985	1986	1987	Total
A-6E	271	271	320	320	320	1,502
F/A-18	2,429	2,358	2,468	2,800	2,800	12,855
F-14	1,157	1,300	1,300	1,300	1,300	6,357
E-2C	323	323	323	323	323	1,615
EA-6B	328	328	328	328	328	1,640
SH-60	--	--	--	858	858	1,716
Total	4,508	4,580	4,739	5,929	5,929	25,685

The F-18 evolved into the multimission F/A-18, which can be rapidly reconfigured from an attack aircraft to a fighter or vice versa, basically in the time required to arm it with the proper ordnance. This adds flexibility to an air wing, although critics maintain that an airplane designed for two missions will do neither mission as well as an aircraft designed for one or the other. The Navy considers it attractive as an attack aircraft because it will be more survivable than the A-7E if attacked by enemy fighters. Finally, the Navy has invested significant sums of money in designing the F/A-18 for high reliability, availability, and maintainability, an investment the Navy sees as paying off in lower maintenance costs and more available flight hours, especially in wartime.

Both its supporters and its critics have been concerned over the cost of the F/A-18. While it is a low-cost fighter, it is much more expensive than the A-7E attack aircraft it would replace. But it is not as expensive relative to other aircraft as some critics maintain. In this respect, it is most often compared with the F-14. The F/A-18s procured in fiscal year 1982 will cost $41 million each (in 1983 dollars) including initial spare parts, while the F-14s procured over the past several years have cost about $43 million each including initial spare parts. (A reduction in the number procured has raised the fiscal year 1983 unit cost to $50 million.) However, the F-14 is nearing completion of its original procurement program, and the Navy is therefore buying the least expensive F-14s, while procurement of the

F/A-18 is just beginning; those F/A-18s remaining to be bought will average $20.0 million each in 1983 dollars, with unit costs decreasing as time goes on. 1/ Therefore, despite perceptions to the contrary, the F/A-18 will be substantially less costly than the F-14 (if the program outlined in the most recent Selected Acquisition Report is actually followed) but about twice as much per unit as the A-7E it is intended to replace.

The Navy has already made a substantial investment in the F/A-18. By the end of fiscal year 1982, 34 percent of the total estimated program cost will have been spent, and the Navy will have procured 157 production aircraft and 11 research and development (R&D) aircraft. The fact that a substantial amount of money has already been invested in the F/A-18 argues against canceling the program. On the other hand, since about 90 percent of the aircraft are still to be bought, the question of its place in the future Navy is relevant.

Alternatives for Modernizing Attack Forces

Four alternative ways of replacing the two squadrons of A-7E light-attack aircraft in each air wing are analyzed here. Each attack force would also include a squadron of ten A-6E medium-attack aircraft.

Option 1: The Navy's Preferred Force

- 24 F/A-18s per air wing;
- Total cost of $12.1-13.3 billion in 1983 dollars.

Option 2: Current Force of A-7Es

- 24 A-7Es per air wing, replacing old A-7Es as they retire with new A-7Es;
- Total cost of $5.5-7.6 billion in 1983 dollars.

1/ This is based upon the program described in the F/A-18 December 1981 Selected Acquisition Report. Slowing down procurement would increase unit costs.

Option 3: Re-engined A-7 Force

- o 24 A-7Xs per air wing;
- o Total cost of $8.2-10.3 billion in 1983 dollars.

Option 4: All A-6E Force

- o 20 additional A-6Es per air wing;
- o Total cost of $8.8-12.5 billion in 1983 dollars.

The estimated costs are in ranges because different cost estimation methodologies have been used.

The primary factor in choosing an attack force ought to be how well it can carry bombs. Other important considerations are the force's ability to survive in a hostile environment and its reliability and maintainability, since those govern the force's long-term capacity to deliver ordnance. The unique multimission capability of the F/A-18 is also an important consideration in deciding which attack aircraft to procure. Of these factors, the ability to carry bombs is the most amenable to credible quantification.

The Navy's Preferred Force. The Navy's preferred light-attack force would consist of F/A-18s. This option would provide good bombing capability at short ranges. Moreover, the F/A-18 has high survivability and can double as a fighter. On the other hand, it has less capability at long bombing ranges than any of the other alternatives. This option would be relatively expensive. Over the next decade, the procurement cost of equipping all light-attack squadrons with F/A-18s would range from $12.1 billion to $13.3 billion in 1983 dollars.

A force equipped with F/A-18s would have a 20 percent greater capacity to deliver bombs (measured in pounds per day) than the current force at ranges up to 500 nautical miles from the carrier. These are the ranges at which the Navy has typically operated in the past. However, improving Soviet capabilities, especially in the form of land-based aircraft and missile-equipped coastal craft may force the Navy to "stand off" and operate at greater ranges. In this case, the Navy's preferred force would be less capable than today's force. Beyond 800 miles, the F/A-18s would have no capability (unrefueled), and all the ordnance would have to be delivered by the A-6Es. At those ranges, the Navy's preferred force would be about 60 percent as capable as the current force.

In the long term, the F/A-18 would have an advantage if F/A-18 wartime attrition, failure, and repair rates are better than those of the other alternatives. During a campaign, the capability of the Navy's preferred force would increase over time relative to the others. If the differences were large enough and the engagement long enough, this could be the determining factor. The advantage would be of little value, however, if operations were conducted at long ranges where the F/A-18s cannot operate.

An added advantage of the Navy's preferred force is that F/A-18s can be flown as fighters. If used to escort an attack, they would free F-14s for fleet air defense. Alternatively, they could augment F-14s in fleet air defense.

A-7E Current Force. The present force of A-7Es could be replaced with new A-7Es. This is by far the cheapest option and would provide better capability than the Navy's preferred force at long bombing ranges. But the A-7E has less capability at short ranges, lacks the F/A-18's ability to double as a fighter, and might be more vulnerable to Soviet fighters. This option would be cheaper than the Navy's preferred force over the next ten years by from $4.5 billion to $7.8 billion, depending upon assumptions about the costs of A-7Es, which are not currently being produced.

While the A-7E force would provide better bombing capability than the Navy option at longer ranges, it would be 20 percent less capable at shorter bombing ranges. The A-7E is a relatively sluggish attack aircraft. In combat, the Navy believes its sluggishness would lead to unacceptable losses from modern Soviet fighters.

Re-engined A-7 Force. The Vought Corporation, which manufactures the A-7E, has defined a re-engined A-7E called the A-7X. This would be supersonic and have other aerodynamic characteristics, especially thrust-to-weight ratio, similar to those of the F/A-18. It would, in Vought's view, be about as survivable in a hostile environment as the F/A-18 is. The A-7X exists only on paper, although it is a marriage of an existing airframe and an existing engine. Buying the A-7X rather than the Navy's preferred F/A-18 would save $1.8 billion to $5.1 billion in procurement costs over the next decade. But the A-7X would still lack the flexibility to double as a fighter and would have less bombing capability at short ranges than the F/A-18.

At target ranges of less than 400 nautical miles, the re-engined option would be about 10 percent less capable than the Navy's preferred option. At longer ranges, however, it would be up to 2.3 times more capable. Compared with the current force, it would be about 15 percent more capable at all ranges.

All A-6E Force. The all A-6E option would replace the A-7E light-attack aircraft with the A-6E, which is currently the Navy's medium-attack aircraft. This approach would provide much better bombing capability at most ranges and might also reduce costs. But the A-6E could not double as a fighter; nor would the all A-6E option be as survivable as the Navy option.

The all A-6E force would provide the air wings with a homogeneous force of medium-attack aircraft able to carry much greater payloads to longer ranges than any light-attack aircraft, and able to attack targets obscured by weather or darkness. Since the A-6E is much larger than the A-7E, only ten are in each squadron. The all A-6E force would be more capable than the Navy's preferred force at all ranges beyond 300 nautical miles, and only slightly less capable at shorter ranges. Beyond 800 nautical miles it would be three times as capable as the Navy's preferred option, and twice as capable as the current force.

The procurement cost of the all A-6E force could be as much as $4.5 billion less than the Navy's preferred force, or it could be slightly higher. This wide range of estimates arises primarily because two different methodologies were applied to estimate the costs at yearly procurement rates about ten times those of recent years. On the other hand, life-cycle costs, which include operating as well as procurement costs, would be about 10 percent less for this option than for the Navy's.

Costs for all four approaches have been stated in terms of procurement costs over the next decade. Over the next five years, however, there would be little, if any, difference among them, and in 1983 probably none at all. Even if an alternative other than the Navy's was selected, procurement of F/A-18s for the Marine Corps would probably continue for at least the next several years, while procurement of alternative attack aircraft would probably be delayed until the mid-1980s to avoid increasing near-term budgets. Thus, while the F/A-18 could be introduced in Navy forces about 1984, the other alternatives would not be available until about three years later.

Alternatives for Modernizing Fighter Forces

Although the F/A-18 was originally designed to be a Navy fighter, and until 1981 the Navy planned to deploy it as such in all air wings except the nine with F-14s, the Navy now wants to put F-14s in all wings on all large-deck carriers. (The Coral Sea and the Midway may receive F/A-18s, but when those ships are retired and replaced by new large-deck carriers the F/A-18s would presumably be replaced with F-14s.) This is based on the argument that the F/A-18 is not the equal of the F-14/Phoenix system in fleet air defense--that is, defending carriers against incoming bombers and their missiles--and that carriers without F-14s would therefore be much less capable of self-defense against a high air threat than those with F-14s. The F/A-18 is thought to be the equal of the F-14 in the role of escorting attack aircraft.

By returning to a plan to equip only 18 fighter squadrons with F-14s and the rest with F/A-18s, the Navy could save a total of $5.8 billion in 1983 dollars over the next five years; eventually, savings would total $7.1 billion. In the Navy's view, this option would result in less overall ability to perform fleet air defense, and therefore less capability to deploy in areas of high air threat.

While this is certainly true, operating policies and distribution of aircraft could be changed so as to minimize the effect of the reduced capability in fleet air defense. Carriers, which often operate in pairs, could be teamed up so that one always had F-14s. Alternatively, ten carriers could be deployed with one squadron of F-14s and one squadron of F/A-18s while each of the remaining four had two squadrons of F-14s. If the F/A-18 were not the light-attack aircraft, those carriers that had a mixture of F-14s and F/A-18s would face more difficult maintenance problems. While either of these changes would provide some F-14 defense against a threat consisting of small numbers of capable aircraft, it would degrade the capability to deal with a Soviet threat consisting of relatively large numbers of such aircraft. Overall fleet air defense, as measured in F-14 flight hours per month, would be degraded.

Carriers equipped with F/A-18s would be able to use them to enhance their attack forces, if air defense requirements permitted. This could increase the weight of bombs delivered to targets at ranges up to 600 nautical miles by about 50 to 75 percent.

CHAPTER I. INTRODUCTION

The Administration has embarked upon a program of expansion and modernization to reverse the long-term decline in the size of the U.S. Navy and to counter the rapidly growing threat posed by the Soviet navy. This program carries forward some elements of the Navy's preexisting modernization program, alters other elements of that program, and adds some new elements. Most notable in the last category are an increase in the number of ships from the current fleet of 535 to about 600 and an increase in the number of deployable aircraft carriers from 12 to 14, with 15 as the Navy's longer-term goal. Accompanying the increase in the number of ships will be the addition of two more carrier "air wings," the replacement of the F-4 fighters remaining in six carrier-based squadrons with the newer F-14, and the replacement of the A-7E light-attack aircraft currently in all air wings with the F/A-18 fighter/attack aircraft. This paper discusses the nature and costs of the Navy's plan for expanding and modernizing its carrier air forces, and possible alternative plans. A companion CBO paper discusses shipbuilding issues in detail. 1/

BACKGROUND

The Navy is structured to a large extent around the deployment of carrier battle groups. While their organization is by no means rigid, a typical battle group consists of two aircraft carriers, several escorting surface combatants (that is, cruisers and destroyers), and logistics ships. In wartime, the missions of carrier battle groups fall in the general categories of power projection, sea control, and sea denial. Briefly, power projection missions involve attacking enemy assets ashore or afloat; sea control and sea denial involve, respectively, keeping a section of ocean safe for U.S. use and making a section of ocean unsafe for enemy use. While these missions differ in purpose, they include many common tasks. For example, in order to project power, a battle group must control a section of ocean from which it can operate in relative safety.

1/ Congressional Budget Office, Building a 600-Ship Navy: Costs, Timing, and Alternative Approaches (March 1982).

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Since the end of World War II, the size of the Navy has decreased steadily and dramatically. Its 12 deployable aircraft carriers today are about half the number the Navy had just two decades ago. 2/ Most carriers in 1962 were significantly smaller than those currently in the fleet. Nevertheless, fewer carriers mean fewer simultaneous deployments, and fewer available ship-days at sea.

During this same period, the Soviet navy has grown from a defensive force mainly operating in contiguous waters to a "blue-water" navy able to deploy worldwide. It may soon acquire aircraft carriers. The U.S. Navy's expansion and modernization program is intended to counter this growing threat. Recently, the Navy has argued that, in order to counter effectively the growing Soviet threat to U.S. shipping, it would have to "bring the war to the Soviets" by using carrier battle groups to attack Soviet ports and bases rather than hunting or countering units on patrol. This would require operating in areas where the threat is most severe.

The expansion would also relieve some of the strain the Navy has encountered in maintaining its peacetime deployment commitments. Until the 1979 Iranian crisis, the Navy maintained four peacetime carrier deployments more or less continuously: two in the Pacific and two in the Atlantic and Mediterranean. These deployments were supported by 13 carriers, each of which spent about one-third of its time on deployment and the remaining time in maintenance and training. In the wake of the Iranian seizure of U.S. hostages, however, routine deployments were begun in the Indian Ocean and the Arabian Sea. Continuing turmoil and U.S. interest in those areas have led to the continuation of these deployments, straining the ability of the Navy to maintain its peacetime commitments with a force that was reduced to 12 deployable carriers when the Service Life Extension program was begun.

2/ Altogether, the Navy has 14 carriers, not including those in "moth balls." The Lexington is used for training only and is not counted as a deployable asset. Of the remaining 13, one is currently undergoing a major overhaul called the Service Life Extension Program (SLEP). When it leaves SLEP, another will begin the program. It is anticipated that one carrier will be in SLEP throughout the 1980s.

In response to these factors, the Administration seeks to expand the fleet to 14 deployable carriers and 14 air wings by the late 1980s. The carrier Vinson entered the fleet in 1982. The Roosevelt is expected to follow at the end of 1986. The introduction of two more carriers, for which funding is requested in the 1983 budget, would allow the retirement of the Midway and the Coral Sea, both of which were laid down during World War II, while maintaining 14 deployable carriers.

Although the Navy has set 15 deployable carriers as a desirable goal, the Administration's five-year shipbuilding plan for 1983-1987 does not support an expansion beyond 14 before the 1990s, unless the Navy decides to retain either the Coral Sea or the Midway. This paper therefore considers the costs of expanding by two carrier air wings. 3/

CARRIER AIRCRAFT

The increase to 14 deployable carriers will require the introduction of one air wing in 1983 and another about 1987. An air wing, or the complement of aircraft assigned to a carrier, includes:

- Attack aircraft for attacking targets ashore and afloat with bombs and missiles;
- Fighters to defend the battle group and its aircraft from air attack;
- Aircraft to hunt submarines;
- Early warning, reconnaissance, and electronic warfare aircraft; and
- Tankers to refuel other aircraft in flight.

3/ The companion study on Navy shipbuilding examines various options to reach the Navy's goal of about 600 ships including 15 carriers; see Congressional Budget Office, Building a 600-Ship Navy. The cost of expanding to 15 air wings can be directly obtained from the analysis presented here.

The composition of a typical air wing is shown in Table 1. Many of its functions are shared by surface combatants, submarines, and land-based aircraft assigned to the battle group.

TABLE 1. COMPOSITION OF A TYPICAL CARRIER AIR WING IN 1982

Aircraft Type	Aircraft	Number of Squadrons	Aircraft per Squadron	Total Aircraft
Medium Attack	A-6E	1	10	10
Light Attack	A-7E	2	12	24
Fighter	F-14 or F-4	2	12	24
Airborne Early Warning	E-2B or E-2C	1	4	4
Electronic Warfare	EA-6B	1	4	4
Tanker	KA-6D	a/	4	4
Reconnaissance	RF-8	1	3	3
Antisubmarine Warfare	S-3A	1	10	10
Antisubmarine Warfare Helicopter	SH-3	1	6	6
Total				89

a/ Part of the A-6E squadron.

Attack Aircraft. The A-6E is a two-seat, twin-engine, subsonic bomber with the unique ability to attack targets obscured by weather and darkness. In addition to bombs and other ordnance for attacking land targets, it carries the Harpoon antiship missile.

The A-7E is a single-seat, subsonic attack airplane with less bomb-carrying capacity than the A-6E. It is more restricted by environmental conditions than the A-6E is. It is also smaller and less costly than the A-6E.

Fighter Aircraft. The F-4 and the F-14 are two-seat, twin-engine fighter-interceptors with top speeds in excess of Mach two. The F-4 was once deployed in all air wings, but the Navy has now replaced the F-4s in all but three wings with F-14s. The F-14 was designed to be the Navy's primary asset for countering high-speed Soviet bombers carrying long-range antiship missiles. It has the unique capability to carry the long-range Phoenix air intercept missile, and the ability to engage several targets simultaneously.

Other Aircraft. The E-2 is a propeller-driven airplane that carries a large radar, similar in appearance to the Air Force airborne warning and control system (AWACS) radar. It performs the same general long-distance air search function that the AWACS does, and also observes the ocean surface.

The EA-6B and the KA-6D aircraft are built on the A-6 airframe and are configured, respectively, for electronic warfare and tanker tasks. The RF-8, a variant of a 1960s Navy fighter, the F-8, is being phased out. Its function will be assumed by three F-14s in each wing equipped with the Tactical Airborne Reconnaissance Pod System (TARPS). The S-3A, no longer in production, is a long-endurance subsonic patrol aircraft that searches for submarines at distances up to several hundred miles from the carrier, while the SH-3 performs a similar function at close range. The Navy plans to replace the SH-3 with the SH-60, not shown in the table.

A New Aircraft--the F/A-18. The F/A-18 is a multimission fighter and attack aircraft, which is now in production but so far deployed only with training squadrons. It is a single-pilot, twin-engine airplane with a top speed of about Mach 1.5. As a fighter, it would carry the medium-range Sparrow and short-range Sidewinder missiles, but not the long-range Phoenix missile carried by the F-14. The F/A-18, which plays a central role in the modernization plans of both the Navy and the Marine Corps, is not included in Table 1, since it has not yet been deployed.

The Navy modernization program that predated the current Administration included equipping nine air wings (18 squadrons) with F-14s; that part of the program is now essentially complete. The other 6 fighter squadrons were to be equipped with F/A-18s. The Navy now plans to buy 10 more squadrons of F-14s, 4 for the two expansion wings and 6 to replace the remaining F-4s. The Navy also plans to establish 28 F/A-18 light-attack squadrons, 4 to equip the new wings and the remaining 24 to replace the A-7Es currently in all wings. The Navy still wants to replace the F-4s on the Coral Sea and the Midway with F/A-18s since these ships are not equipped to handle F-14s. However, if the Navy is to reach its goal of F-14s on all large-deck carriers, these four squadrons would have to be replaced with F-14s when the Coral Sea and the Midway are retired and replaced with two new Nimitz-class carriers in the late 1980s or early 1990s.

ISSUES FACING THE CONGRESS

The largest single DoD procurement issue facing the Congress in fiscal year 1983 is whether or not to fund two more carriers. In deciding this issue, the Congress will be deciding on the number of carriers and the number of air wings in the Navy. Although the Congress would have to approve funding for the aircraft for these wings separately, by approving expansion to 13 or 14 carriers it would be accepting a requirement for that many air wings. It would not be asked to approve funding for each new air wing all at once, or indeed in any identifiable form; rather, it would be asked on a year-by-year basis, beginning in fiscal year 1983, to approve the funding necessary to build and maintain the proper inventory levels for the number of air wings the Navy will have.

The Administration's 1983 budget request includes funding for the first F-14s for the 10 additional fighter squadrons. If the Navy had continued with its former plan to equip only 18 squadrons with F-14s, F-14 procurement would have terminated with a reduced buy in 1983. The Congress must decide whether to ratify the new plan. A decision by the Congress not to fund the additional F-14s in 1983 would not mandate a return to the former plan, but a similar decision in 1984 probably would. 4/ Similarly, a decision

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4/ The F-14 production line would stay open at some level for several years to complete those aircraft under construction.

to fund the full request in fiscal year 1983 would not require following the new plan to equip all carriers with F-14s; the Congress could decide to terminate F-14 procurement at a later date.

The Congress has been faced with the F/A-18 program for several years. By fiscal year 1983, about one-third of the estimated cost of the total program will have been appropriated to develop and produce 157 of the planned 1,366 airplanes. This argues against outright cancellation of the program, but it is not yet clear what part the F/A-18 will ultimately play in the Navy's force structure. The Congress will have to decide whether it concurs with the view that the F/A-18 is a suitable fighter for the Marine Corps but not for the Navy, and also whether to fund the procurement of the F/A-18 as the Navy's new light-attack aircraft replacing the A-7E.

SCOPE OF THE PAPER

This paper does not directly address the issue of the value of expanding the Navy by two carriers and two air wings. It does, however, present the cost of adding air wings. It also analyzes the costs associated with the Navy's plan to modernize fighter and attack squadrons, and compares possible alternatives.

Chapter II addresses the total costs of the Navy's plan to add two air wings and to replace all remaining F-4s with F-14s and all A-7Es with F/A-18s. Chapter III analyzes alternative approaches to modernization.

CHAPTER II. THE COSTS OF THE NAVY'S EXPANSION AND MODERNIZATION PLAN

This chapter presents the costs of the Navy's plan to create two new carrier air wings, replace all remaining F-4s with F-14s, and replace all A-7Es with F/A-18s. It then briefly examines the Administration's five-year plan for procurement of naval aircraft. All costs are in 1983 dollars unless otherwise specified.

LONG-RUN COSTS OF EXPANSION AND MODERNIZATION

The total procurement cost of the Navy's plan would be $30 billion in 1983 dollars. This includes the cost of aircraft placed in the squadrons, of aircraft added to training squadrons and the repair pipeline, and of aircraft purchased in advance to replace peacetime losses for 15 years. About 40 percent of the amount would pay for the two additional carrier wings, while the remainder would pay for modernizing the existing wings.

Cost of Additional Air Wings

Each new wing would cost $5.6 billion in procurement and add about $200 million per year in operating costs. This estimate assumes procurement of the Navy's most modern types of aircraft, including F-14 fighters and F/A-18 light-attack aircraft. It also assumes that the S-3 production line would be reopened and that the SH-60 helicopter would replace of the SH-3. 1/

The composition of a new air wing is shown in Table 2. Table 3 itemizes the procurement and operating costs for each new air wing. The methodology used in generating these figures is described in Appendix B. The aircraft for each wing, plus the additional aircraft required for the Fleet Replenishment Squadrons (training squadrons) and the repair pipeline, would cost about $4.2 billion. If only these aircraft were bought, however,

1/ The S-3 line was closed with provision to reopen, and the tooling put into storage.

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TABLE 2. COMPOSITION OF AN EXPANSION AIR WING

Aircraft Type	Aircraft	Number
Medium Attack	A-6E	10
Light Attack	F/A-18	24
Fighter	F-14	24 a/
Airborne Early Warning	E-2C	4
Electronic Warfare	EA-6B	4
Tanker	KA-6D	4
Antisubmarine Warfare	S-3A	10
Antisubmarine Warfare Helicopter	SH-60	6
Total		86

a/ Including three with the Tactical Airborne Reconnaissance Pod System (TARPS).

these initial inventories would decrease as operations began and aircraft were lost during peacetime operations. In order to maintain inventories, additional aircraft must be procured either in advance or at some rate that keeps pace with anticipated peacetime attrition. 2/ The most economical approach is to buy them in advance at the same production rates as active inventory aircraft; that is what is assumed here. Therefore, Table 3 assumes that the unit cost of the attrition aircraft is the same

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2/ Aircraft cannot be procured as the need arises because the entire process of budget request, appropriation, and construction would take several years.

TABLE 3. COSTS OF PROCURING AND OPERATING ONE CARRIER AIR WING (In millions of fiscal year 1983 dollars)

Aircraft	Long-Run Procurement: Excluding attrition aircraft	Long-Run Procurement: Including attrition aircraft for 15 years	Average Yearly Attrition	Total Yearly Operating Costs
A-6E	454	555	6.7	34 a/
F/A-18	585	852	17.8	44
F-14	1,559	2,235	45.1	46
E-2C	377	400	1.5	12
EA-6B	328	510	12.1	16
KA-6D	172	222	3.3	-- a/
S-3A	607	712	7.0	27
SH-60	107	152	3.0	23
Total	4,194	5,643	96.4	202

SOURCE: See Appendix B.

a/ KA-6D operating costs are included in the A-6E total.

as that of the other aircraft. If attrition aircraft were procured each year at the rate at which aircraft were lost in service, the procurement rates would be lower and the unit costs would be higher than those assumed here. The table includes the cost of attrition aircraft for 15 years. This period is somewhat arbitrary; it is the service life of the F-14 and F/A-18, although the other aircraft in the table have longer service lives.

An Alternative Division of Costs. An alternative way of calculating costs would be to include the costs of attrition aircraft in the average yearly operating costs. Viewing the costs in this manner avoids the need to assume a specific length of time for which attrition aircraft should be procured. If no aircraft were initially bought in anticipation of attrition, the total cost of equipping one wing would be $4.2 billion, and operating costs would then average about $300 million per year, about one-third of which would be average annual costs for attrition aircraft.

Reopening the S-3 Production Line. The totals described above include procurement of additional S-3A antisubmarine warfare (ASW) aircraft. The S-3 production line is now closed, however, and reopening it does not appear in either the budget or the Administration's five-year plan. If more S-3s were not built, carriers could be equipped by redistributing existing inventories of S-3A aircraft, reducing the number per air wing. This would reduce the initial procurement cost of each new wing by $0.6 billion, and the average annual attrition cost by $7 million. Continued peacetime attrition would then require continuous downward adjustments in operating levels until operations became impractical.

Costs of Modernization Alone

Fighters. Adding six more F-14 squadrons to the existing air wings would require the procurement of 155 additional F-14s. This number includes aircraft for the six squadrons, additions to the Fleet Replenishment Squadrons and repair pipeline, and attrition for 15 years. At current rates of production, these airplanes would cost $6.7 billion. The number of active F-14 squadrons (including those in the new wings) would increase gradually over time. When the first squadron had been in operation for 15 years, the last would be five to ten years old. Buying attrition aircraft for 15 years for the entire force would therefore actually allow the force to operate somewhat longer than 15 years, since it would be at less than full strength for the first several years, and would therefore lose aircraft at a slower rate during those years.

Light-Attack Aircraft. Replacing the 24 existing A-7E squadrons with F/A-18 squadrons would require 594 airplanes, including advance attrition aircraft for the entire force. If these aircraft were charged at the average estimated unit cost of the entire 1,209 F/A-18s remaining to be procured, they would cost $11.9 billion. 3/

3/ The total number of F/A-18s to be procured is 1,366; of that number, 157 have been appropriated through 1982.

TABLE 4. ADMINISTRATION REQUEST FOR CARRIER AIRCRAFT PROCUREMENT (By fiscal year)

Aircraft	1983	1984	1985	1986	1987
A-6E	8	8	12	12	12
F/A-18	84	96	108	132	132
F-14	24	30	30	30	30
E-2C	6	6	6	6	6
EA-6B	6	6	6	6	6
SH-60	--	--	--	64	64

FIVE-YEAR COSTS

Over the next five years, the Navy plans to procure 936 aircraft of types deployed on aircraft carriers at a total cost of $26 billion (see Tables 4 and 5). This sum does not include the full costs of the expansion and modernization plan, nor the yearly costs of that plan, nor the Navy's complete expenditure for aircraft over five years, for the following reasons:

- o The expansion and modernization will take more than five years;
- o Some of these aircraft are also being procured for other purposes;
- o Those aircraft that are being procured for expansion and modernization cannot be separated from those that are for other purposes; and
- o The Navy will also buy types of aircraft that will not be deployed on carriers.

During these five years, the Navy will also purchase P-3C land-based patrol aircraft, helicopters for deployment on surface combatants, AV-8B Harriers for the Marine Corps, C-9 transports, and other aircraft not included in the tables. Some of the aircraft, such as the A-6E, the EA-6B, and the E-2C, are also being procured to fill shortfalls in existing inventories. Some, such as the A-6E and the F/A-18, are also being procured for the

TABLE 5. COSTS OF CARRIER AIRCRAFT PROCUREMENT (By fiscal year, in millions of 1983 dollars)

Aircraft	1983	1984	1985	1986	1987
A-6E	271	271	320	320	320
F/A-18	2,429	2,358	2,468	2,800	2,800
F-14	1,157	1,300	1,300	1,300	1,300
E-2C	323	323	323	323	323
EA-6B	328	328	328	328	328
SH-60B	--	--	--	858	858

Marine Corps. There is no way of determining which of the aircraft being procured each year are for expansion and modernization, or what the procurement rates would be in the absence of expansion and modernization. Aircraft are procured to support inventory objectives and are assigned as needed. For example, the aircraft for the wing to be established in 1983 would be taken from other parts of the inventory (training, inactive inventory, and so on), while actual procurement would be directed to keeping the inventory at authorized levels. Thus, the airplanes for the new wing do not appear explicitly in the five-year plan, although they must clearly be paid for. Finally, this five-year plan includes no procurement of S-3A antisubmarine warfare aircraft.

THE IMPACT OF PRODUCTION RATES ON THE RATE OF EXPANSION

The condition of U.S. defense industries has been a matter of interest and concern over the past several years; at least one major Congressional hearing has been held on the subject. 4/ In particular, doubt has been expressed that ships, aircraft, and other items can be produced at the rates required to support the Navy's plan. The evidence suggests, however, that the Navy's plan can be implemented by continuing production of most types at rates that have prevailed in recent years while following new programs as planned. This is discussed in Appendix C.

4/ Capability of U.S. Defense Industrial Base, Hearings before the House Armed Services Committee, 97:1 (1980).

Further, according to data collected by the Naval Air System Command, much idle capacity now exists in companies that produce aircraft for the Navy. Most current aircraft types are being produced at below-capacity rates.

Indeed, problems in producing more weapons, if they occur at all, are more likely among the so-called "second tier" of manufacturers that produce electrical and other components for ships and aircraft rather than among the prime contractors that assemble the weapons. The current recession suggests that, in the near term, problems are unlikely even in this second tier of producers. But, as the economy recovers, bottlenecks could occur. Unfortunately, little data exist to predict precisely the scope of such bottlenecks. 5/

5/ For further discussion, see "Defense Spending and the Economy," statement of Alice M. Rivlin, Director, Congressional Budget Office, before the House Committee on Armed Services, February 1982.

CHAPTER III. ANALYSIS OF ALTERNATIVE APPROACHES TO MODERNIZING FIGHTER AND ATTACK FORCES

The preceding chapters have presented the rationale for and costs of the Navy's planned expansion and modernization of its carrier air forces. Much of the spending would be for expanding and modernizing the fighter and attack forces. This chapter analyzes in more detail the Navy plan for modernizing those forces and alternatives to that plan.

In 1981, the Navy revised its modernization plan by reducing the role of the F/A-18 as a carrier-based fighter in favor of F-14s on all large deck carriers, while reaffirming its choice of the F/A-18 as an attack aircraft. The Navy's goal of replacing the A-7Es and the remaining F-4s, could also be reached by equipping with F/A-18s all those fighter squadrons for which F-14s have not yet been procured, by equipping attack squadrons with something other than the F/A-18, or both. Because the F/A-18 is of central importance to any discussion of the Navy plan or alternatives, this chapter begins with a discussion of that program.

THE F/A-18 PROGRAM

The F/A-18 began as the F-18, originally conceived as a lower-cost complement to the F-14. It was based on the YF-17, which lost in the competition for the selection of the Air Force lightweight fighter, the F-16. The F-18 evolved into the F/A-18, an aircraft that can be used as either an attack aircraft (bomber) or a fighter by selecting the appropriate armament.

The Navy has had a continuing interest in a fighter/attack aircraft. Deploying a carrier with a pure fighter force, a pure attack force, and a "swing force" would add flexibility, since aircraft could be more efficiently allocated between the two missions in response to evolving circumstances. The Navy could use the fighter capability of the F/A-18s in attack squadrons to provide a short-range complement to the long-range capability of the F-14s in fleet air defense and to escort attack aircraft, freeing more F-14s for fleet air defense. Although it is acknowledged to be at least the equal of the F-14 as a dogfighter, the F/A-18 lacks the long-range weapon system that makes the F-14

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the Navy's preferred interceptor for fleet air defense. The argument for the F/A-18 as a fighter has always been primarily one of cost.

The program goal for the F/A-18 is 1,366 aircraft. This number was initially arrived at based upon a requirement to equip 24 Navy light-attack squadrons (two squadrons per carrier on each of 12 carriers), six Navy fighter squadrons (two squadrons per carrier on each of three carriers, the remainder having F-14s), and Marine Corps fighter and attack squadrons, as well as to supply some trainer and reconnaissance aircraft. During 1981, the Administration decided to procure the new version of the Harrier vertical take-off and landing aircraft (the AV-8B) for the Marine Corps attack aircraft, increase the number of Navy F/A-18 attack squadrons to 28, and eventually equip all Navy fighter squadrons with the F-14. 1/ This last step was justified on the ground that every carrier should have the superior air defense capability provided by two squadrons of F-14s. Nevertheless, the F/A-18 program goal remained at 1,366. Some F/A-18s may go directly to the reserves.

Description

The F/A-18 is a supersonic, twin-engine, single-seat aircraft that, when flown as a fighter, carries both the Sidewinder short-range air-to-air missile and the Sparrow medium-range air-to-air missile. Unlike some "fighter/bombers" that are produced in either a fighter or a ground attack configuration, the F/A-18 can perform either mission when given the appropriate weapon load. This characteristic makes it especially attractive to the Navy, which must fight with small numbers of aircraft at long distances from supply bases. In times of high air threat, a carrier could use its F/A-18 attack aircraft as fighters in fleet air defense or for escort of other attack aircraft, thus freeing more F-14s for fleet air defense.

1/ F/A-18s may be deployed in the fighter squadrons assigned to the Coral Sea and the Midway. However, if the Administration goal of F-14s on all the large deck carriers is to be realized, those F/A-18s will be replaced by F-14s when these carriers retire and their air wings are transferred to new Nimitz-class carriers.

The F/A-18 is generally considered to be equal to the F-14 in agility, although its maximum speed is lower. It is not equipped with either the long-range Phoenix air-to-air missile or a radar that is appropriate for the employment of the Phoenix.

In an attack mission, the F/A-18 would have a greater payload than the A-7E at short ranges, but a smaller payload at long ranges. The A-7E has become increasingly vulnerable to hostile action as the capabilities of Soviet systems have improved and as increases in its avionics and payloads have eroded its aerodynamic characteristics. It has lower speed, maneuverability, and thrust-to-weight ratio than the F/A-18.

In designing the F/A-18, the Navy has placed a premium on high reliability, availability, and maintainability (RAM). Low RAM has been a problem with many modern aircraft. It is of particular concern to the Navy because a carrier has limited aircraft assets, limited maintenance capability, and limited resupply capability at long distances. The Navy sees high RAM as one important advantage of the F/A-18 over the A-7E.

The F/A-18 is somewhat larger than the A-7E, which might mean that in the future a carrier would have two or three fewer airplanes than at present. 2/

Costs

The F/A-18 is not an inexpensive airplane, but it is not as costly relative to other aircraft as some of its critics maintain. Its costs are often compared unfavorably with those of the F-14. Unit costs for the F/A-18 over the life of the program are variously quoted at between $25 million and $40 million, in dollars adjusted for inflation up to the 1990s. Program unit costs for the F-14 are said to be $20 million to $25 million, in dollars spent during the 1970s. F/A-18s procured in fiscal year 1982 cost $38 million each (in then year dollars) including initial spare parts, while F-14s procured in 1982 cost about $39 million each with initial spare parts. But this is not the most

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2/ The installation of the Tactical Airborne Reconnaissance Pod System on three F-14s in each wing will permit the retirement of the three RF-8 reconnaissance aircraft currently carried, making more space available.

relevant basis for comparison. The F-14 is nearing completion of its original procurement program, so that the Navy is now buying the least expensive units (in constant dollars), while procurement of the F/A-18 is just beginning. The F/A-18s remaining to be bought will average $20.0 million each in 1983 dollars ($21.1 million if the 1982 buy is included), with unit costs decreasing as time goes on. 3/ Therefore, despite perceptions to the contrary, the F/A-18 will be substantially less costly than the F-14 if the program outlined in the Selected Acquisition Report (SAR) is actually followed. On the other hand, the F/A-18 is more costly than comparable attack aircraft. The A-7E costs only about $11 million in 1983 dollars. The A-6E medium attack aircraft currently costs about $27 million, but is being procured at an inefficient rate.

Finally, the Navy has already made a substantial investment in the F/A-18. By the end of 1982, 34 percent of the currently estimated cost (in constant dollars) of the total program will have been spent, and 157 production aircraft and 11 research and development (R&D) aircraft will have been procured.

ALTERNATIVE ATTACK AIRCRAFT

This section examines four alternative forces for replacing the Navy's light-attack squadrons.

Option 1: The Navy's Preferred Force

- 24 F/A-18s per air wing;
- Total cost of $12.1-13.3 billion in 1983 dollars.

Option 2: Current Force of A-7Es

- 24 A-7Es per air wing, replacing old A-7Es as they retire with new A-7Es;
- Total cost of $5.5-7.6 billion in 1983 dollars.

3/ This is based upon the program in the Defense Department's December 1981 F/A-18 Selected Acquisition Report (SAR). Reducing procurement rates from those upon which the SAR is based would increase unit costs.

Option 3: Re-engined A-7 Force

- 24 A-7Xs per air wing;
- Total cost of $8.2-10.3 billion in 1983 dollars.

Option 4: All A-6E Force

- 20 additional A-6Es per air wing;
- Total cost of $8.8-12.5 billion in 1983 dollars.

Aircraft Description

The A-7E. The A-7E entered the fleet in 1970. It is a single-seat, single-engine, subsonic aircraft designed to complement the A-6E. The A-7E does not have the A-6E's mission of attacking targets totally obscured by darkness or weather. It has less range and a smaller payload than the A-6E, but it costs less and requires less space on the carrier per aircraft.

The A-7X. Vought Corporation, the manufacturer of the A-7E, has designed two new A-7 models which it designates A-7X. The A-7X is not part of the official Navy program, and no prototype of it exists. Since it represents a combination of an existing airframe and an existing engine, it is somewhat more than a "paper airplane." It is not likely that the A-7X could go into production for several years, however. Of the two A-7X models, the one considered here is a supersonic aircraft with a thrust-to-weight ratio and other aerodynamic characteristics somewhat similar to those of the F/A-18.

While Vought does not claim that the A-7X would have all the capability of the F/A-18 as a fighter, it would have some, especially in the escort mission. It could evade or engage when attacked considerably better than the A-7E does. The A-7 airframe is based upon that of the F-8, a Vietnam-era fighter. As an attack aircraft, the A-7X could carry a somewhat greater payload than the A-7E, but less at short ranges than the F/A-18. It would be roughly the same size as the A-7E. Like the A-7E, it is a single-seat airplane.

The A-6E. The A-6E now in Navy medium-attack squadrons enables the Navy to attack targets in "all weather" conditions and at greater ranges than those to which light-attack aircraft can fly, and has a substantial payload advantage over light-attack aircraft at longer ranges. It carries a crew of two and is substantially larger than the A-7E.

Estimating the Capability of Alternative Forces

The mission of attack aircraft is to attack targets ashore and afloat with bombs and guided missiles. The primary measure of effectiveness of an attack force is the number of pounds of ordnance it is capable of delivering to a target area during an operating period. This section presents the results of a calculation of the number of pounds of bombs that could be delivered to a target area in the course of a single 12-hour operating day by each of the four alternative forces of attack aircraft operating in conjunction with the one medium-attack squadron on the carrier. It takes the following factors into account: aircraft range and payload characteristics; the rate at which a carrier can launch, recover, and service aircraft; and mission availability rates. A constant fraction of the launches are of aircraft other than attack aircraft. This only affects the calculated capacity at short ranges; at other ranges, there are not enough attack aircraft available to fill all the launch slots allotted to them. The calculation assumes a "high-low-high mission" profile. 4/ The calculation is described in more detail in Appendix A.

Findings. The results of the calculation for the four alternative forces are shown in Figure 1 as a function of range to target. Figure 2 presents the same results in a different way--as the capabilities of each of the alternatives relative to the Navy's preferred force.

The capability of all four forces drops off rapidly as range increases, especially between 250 and 350 nautical miles. All forces deliver large quantities of bombs at short ranges, while none of the forces performs well in absolute terms at very long ranges.

In general, at ranges up to 300 nautical miles the Navy's preferred force performs better than the other three forces, but

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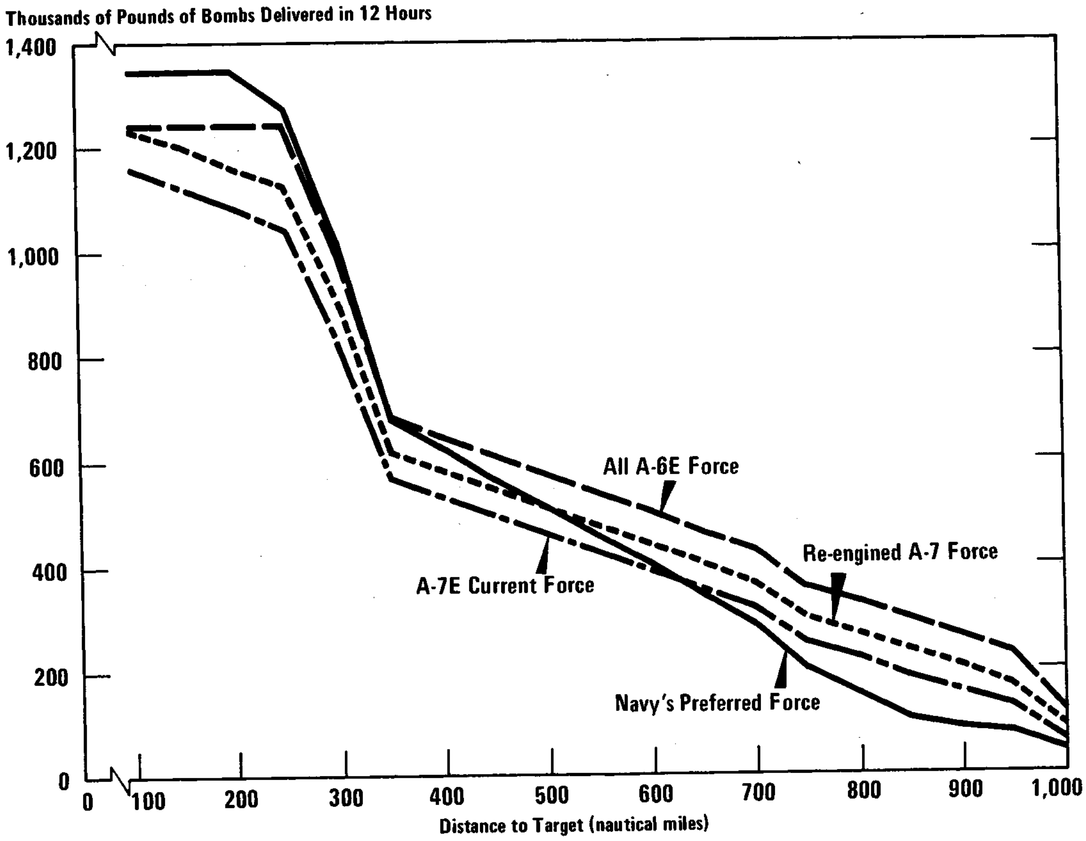
4/ In a high-low-high mission, the airplane flies to the vicinity of the target at high altitude, descends to attack, and climbs to cruising altitude for its return to the carrier.

Figure 1.
Capabilities of Alternative Attack Forces

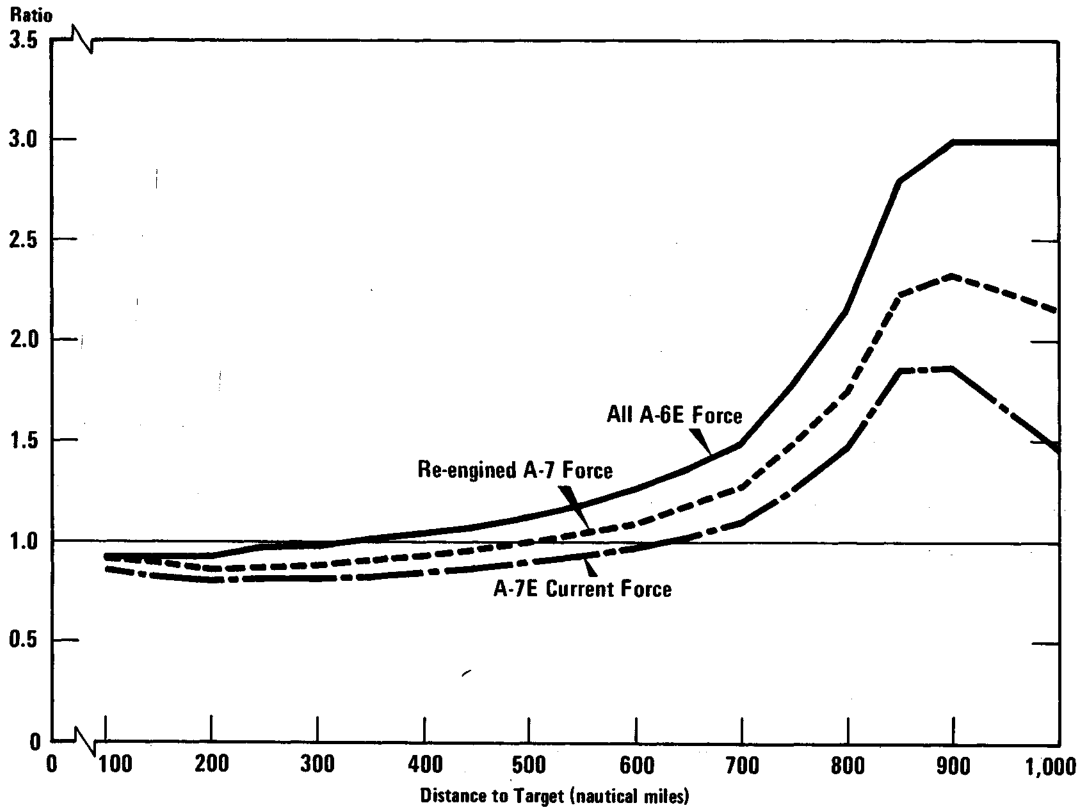


not by a wide relative margin. At ranges beyond 600 nautical miles, the three alternatives become much more capable than the Navy's mix, and they display substantial relative advantages over the Navy's mix beyond 800 nautical miles. From 300 to 600 nautical miles, the A-7X force is about equal in capability, on the average, to the F/A-18 force; the A-7E force is less capable; and the all A-6E force is more capable.

This calculation is in terms of the total ordnance delivery capacity of an attack force. The total capacity may not always be used, due to operational constraints, especially at short range.

Figure 2.

Ratios of Bomb Delivery Capacities of Alternative Forces to That of Navy's Preferred Force



However, a force with a higher delivery capacity can accomplish the same mission with fewer sorties than a force with a lower delivery capacity, freeing carrier launch slots for other missions such as fleet air defense or antisubmarine warfare.

The best case for the F/A-18 is made at short ranges, but differences among the alternatives are not great at these ranges. While the Navy has preferred to operate at ranges of 100 to 300 nautical miles, actual combat may involve greater distances. When attacking targets ashore, natural hazards or the presence of coastal defense craft could dictate perhaps 100 to 300 miles of stand-off from shore. In addition, not all targets will be directly on the coast, so that distance inland will have to be added to that from shore. Moreover, antiship cruise missiles and the development of Soviet ships operating aircraft will increasingly require stand-off of a few hundred miles when attacking Soviet naval forces.

Carriers will not be able to operate sufficiently far from shore to avoid attack by long-range Soviet bombers such as the Backfire, which have much greater range than all carrier aircraft. They might well operate beyond the normal operating ranges of shorter-range Soviet attack aircraft and beyond the ranges to which Soviet fighters could accompany bombers. The Soviet aircraft available for attacking carriers and other ships are the Su-17 Fitter D and H with a range of 475 nautical miles, the MiG-27 Flogger D and J with a range of 550 nautical miles, and the Su-24 Fencer A with a range of 975 nautical miles. 5/ Avoiding those aircraft would require stand-off distances at least equal to their ranges. Seven different Soviet fighters have ranges of 475 to 775 nautical miles. A carrier would have to operate about 100 nautical miles beyond the ranges of these fighters in order for the F-14s to be able to intercept a bomber after it has left the protection of its fighters and before it can launch a missile at the carrier. If the bases from which these Soviet aircraft operated were between the carrier and its target area, the range to which the carrier attack force would have to fly would be even greater.

At the longest ranges (800-1,000 nautical miles) the three alternatives, and especially the A-6E, have greater capability than the F/A-18. While naval aircraft cannot mount a very large attack at such ranges, the capability to attack at long range may be necessary if the Navy wants to be able to attack Soviet bases, particularly in the initial period of combat.

At middle ranges of 300 to 600 nautical miles, the all A-6E force has superior capability to the Navy's preferred mix, the A-7X force has about the same capability, and the A-7E has less capability.

Factors Not Included. The calculation does not include all the factors affecting capability. Some, like accuracy of

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5/ This range information is obtained from Department of Defense, Soviet Military Power.

bomb delivery, would not alter the results in any significant way. Others, like the ability of the F/A-18 to perform fighter missions have no effect on these results but could prove important in certain scenarios. Still other factors cannot easily be quantified, but need to be included in any comparison of attack aircraft.

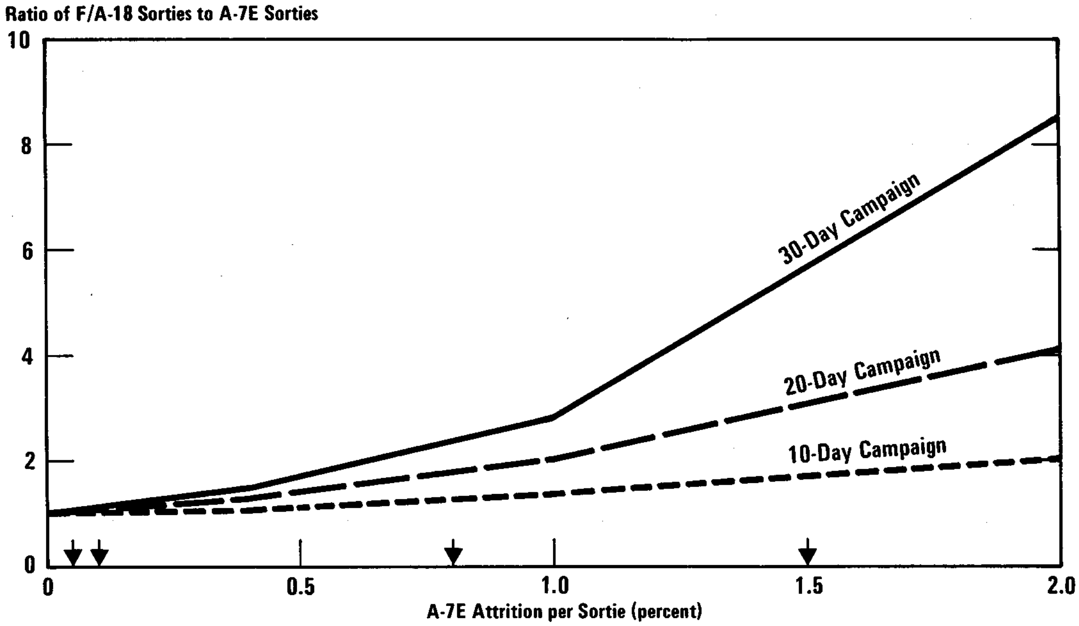
Accuracy of Delivery. This model has not included the accuracy with which an airplane delivers bombs to a target. All these airplanes can launch guided missiles, the accuracy of which is basically independent of aircraft characteristics. All carry similar devices--radars and Forward Looking Infrared systems and fire control computers--for locating targets and determining launch points for gravity bombs. The A-7E and A-6E have similar accuracy for the release of bombs, and it is anticipated that the F/A-18 will, and the A-7X could, have the same accuracy. However, the A-6E has the advantage of a two-man crew, which permits more attention to be paid to those functions associated with the delivery of weapons. It is the Navy's all-weather, day/night attack bomber "equipped specifically to deliver . . . weapons on targets completely obscured by weather or darkness." 6/ Thus, there are conditions under which the A-6E could operate, while the others could not. This difference, although not easily quantifiable, should be taken into account.

Attrition Rates. Attrition due to enemy action has also not been taken into account. Inclusion of reasonable average wartime attrition rates would alter the total weight of bombs delivered in a single day by only about 1 percent. Over several days or weeks, however, relatively small attrition rates could have large consequences. For example, at 3 percent attrition per day, 40 percent of a force would remain after 30 days. At 1 percent, 74 percent, or nearly twice as much, would remain. Higher attrition not only means higher replacement rates, it also means fewer sorties for carrier-based aircraft that cannot be replaced. A force sustaining 1 percent attrition would fly roughly twice as many sorties in 30 days as one sustaining 3 percent attrition. To the extent that the F/A-18 is more survivable than the A-7E, it could be much more effective over an extended battle. How much more effective depends upon the length of the battle and the difference in attrition rates. No attempt has been made to predict what these factors might be, but their effect can be demonstrated by a parametric treatment.

6/ Jane's All the World's Aircraft, 1980-81.

Figure 3.

How a Three-to-One Advantage in Attrition Rates Would Affect the Ratio of Sorties by F/A-18s to Sorties by A-7Es Over the Course of a Campaign



NOTE: The aircraft are assumed to make five sorties per day. The range of attrition rates shown on the horizontal scale may be compared with historical rates of 1.5 percent per sortie for Israeli A-4s in the Yom Kippur War (1973), 0.8 percent for all Israeli aircraft in the same war, 0.1 percent for U.S. Navy aircraft over North Vietnam (1965-1973), and 0.05 percent for Navy aircraft over all of Southeast Asia (1965-1973).

The importance of different attrition rates can be illustrated. An earlier Congressional Budget Office report compared the A-7E and the F/A-18, partially on the basis of relative attrition rates. 7/ That report employed a Navy estimate that A-7E attrition would be about three times F/A-18 attrition. Using that assumption, Figure 3 shows how the ratio of sorties generated by a force of F/A-18s to sorties generated by an equal number of

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7/ Congressional Budget Office, Navy Budget Issues for Fiscal Year 1980 (March 1979).

A-7Es would increase over the course of a campaign, assuming five launch cycles per day and assuming that no new aircraft replaced those lost by the carrier. Clearly, under certain circumstances, a factor-of-three improvement in survivability could, if realized, be very important. It must be stressed, however, that absolute attrition rates, relative attrition rates, and length of campaign are "soft" numbers that lack the accuracy of factors such as ranges and payloads.

Reliability and Maintainability. The calculation presented in Figures 1 and 2 considers only a single day, during which differences in operational readiness, mean time to fail, and mean time to repair (as well as combat attrition) would have a relatively minor effect. Thus the calculation may ignore a large advantage of the F/A-18, if the Navy's investment in reliability and maintainability proves effective.

Refueling. All of these airplanes can be refueled in flight, extending their ranges. If refueling were included in the calculation, it would increase the capabilities of all four forces, but would not alter the relative differences among them.

Newer Technology. The F/A-18 is a much newer airplane, technologically, than the others. New techniques have been incorporated to aid the pilot in operating the airplane and its weapon systems. The effect of this on operational capabilities is difficult to quantify plausibly.

Multimission Capability. A major characteristic of the F/A-18 that is not captured in the analysis and is difficult to quantify is the ability of the airplane to fly either fighter or attack missions on short notice. It has a radar for air combat and can carry Sidewinder and Sparrow missiles. F/A-18s placed in attack squadrons could also be used to augment fighters in fleet air defense, or to escort attack planes and thus free fighters for fleet air defense. F/A-18s flying attack missions (and properly armed) would have a reasonable chance of escaping from, or successfully engaging, enemy fighters. The A-6E and the A-7E would be no real match for a fighter because they are relatively poor in acceleration and maneuvering and their radar is inadequate for air combat, although they carry Sidewinder missiles for self-protection. The A-7X, if developed as advertised, could have some or many of the fighter capabilities of an F/A-18. With the appropriate radar, it could operate the Sparrow missile. How important one considers this multimission capability to be depends upon a judgment as to the adequacy of carrier fighter forces. If fighter forces are insufficient, augmentation would be useful. If current fighter forces are much more than adequate, the ability to augment them would be of marginal utility. Scenarios in which more fighters are needed can always be created. The value of the F/A-18 multimission capability will ultimately turn upon how plausible (and likely) those scenarios are believed to be, and how much the Navy and the Congress are willing to pay for the capability.

Costs of Alternative Forces

Long-Run Procurement Costs. The costs of procuring enough aircraft to equip 28 squadrons (14 carrier air wings) are shown in Table 6, for each of the four alternatives.

The cost of the F/A-18s is the cost of the last 693 aircraft in the current program. This is the cost that would be avoided if some other option were chosen. In Chapter II, F/A-18s were costed at the average unit cost for the entire program (excluding those already procured). The range of costs shown in the table for the F/A-18 results from different assumptions regarding the distribution of support costs within the program.

TABLE 6. PROCUREMENT COSTS OF ALTERNATIVE ATTACK AIRCRAFT FORCES

Option	Aircraft	Number Procured a/	Total Cost (billions of 1983 dollars)
Navy Preferred	F/A-18	693	12.1 - 13.3
Current Force	A-7E	700	5.5 - 7.6
Re-engined A-7s	A-7X	700	8.2 - 10.3
All A-6Es	A-6E	583	8.8 - 12.5

a/ Includes aircraft for carrier squadrons, for training, for repair pipeline, and for 15 years' estimated attrition.

The ranges of costs presented for the A-7E and A-7X arise from differences between contractor estimates and estimates using assumptions generated by the Navy. Compared with the Navy's preferred option, the current force option would save $4.5 billion to $7.8 billion. The re-engined A-7 option would save $1.8 billion to $5.1 billion.

The range of costs for the all A-6E option stems from a somewhat different source. These aircraft are currently being procured at a rate of 8 to 12 per year. In order to produce 583 additional A-6Es in a reasonable period of time, the rate would have to be accelerated to about 96 per year. Two models have been developed for predicting unit costs when the yearly buy rate changes, but few data exist upon which to base a projection for such a large change in the buy rate. 8/ Using one model and various assumptions (including those provided by the manufacturer) produces costs that range from $8.8 billion to $10.0 billion. Using the other model produces costs of $11.2 billion to $12.5 billion. The procedure is discussed more fully in Appendix B. The A-6E option could thus be as much as $4.5 billion less costly than the F/A-18 or $0.4 billion more costly.

Life-Cycle Costs. The cost comparisons in Table 6 show the differences among the four options in the cost of procuring the aircraft required to establish the squadrons and operate them for 15 years. They do not capture all the cost differences associated with owning and operating these forces. In particular, there are differences in yearly operating costs. The aircraft also have different service lives, which means that the value of the aircraft remaining after 15 years would differ from type to type. An F/A-18 would reach the end of its service life in 15 years and would have to be replaced, whereas an A-6E with a service life of 23 years would have eight years of service left after 15 years. Table 7 shows the total 15-year cost of each of the alternatives (not including the 10 A-6Es common to all alternatives). The "procurement" cost shown is obtained by calculating a procurement

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8/ See the descriptions by Commander Steve J. Balut, "Three Views of the Impact of Production Rate Changes: I. Redistributing Fixed Overhead Costs," Concepts: The Journal of Defense Systems Acquisition Management, vol. 4 (Spring 1981), pp. 63-76; and John C. Bemis, "Three Views of the Impact of Production Rate Changes: III. A Model for Examining the Cost Implications of Production Rate," Concepts, pp. 84-94.

TABLE 7. FIFTEEN-YEAR TOTAL COSTS OF ALTERNATIVE ATTACK AIRCRAFT FORCES

Option	Aircraft	Service Life (years) a/	Procurement (billions of 1983 dollars) b/	Yearly Operation (millions of 1983 dollars per aircraft) c/	Total 15-Year Cost (billions of 1983 dollars) d/
Navy Preferred	F/A-18	15	12.1-13.3	2.22	26.1-27.3
Current Force	A-7E	17	5.1-7.0	1.74	16.1-18.0
Re-engined A-7s	A-7X	13 e/	8.5-11.4	1.91 e/	20.5-23.4
All A-6Es	A-6E	23	6.4-9.0	2.86	21.4-24.1

a/ Supplied by the Navy, except for A-7X.

b/ That part of procurement including attrition aircraft that would be incurred in 15 years if the procurement costs were evenly spread over the full service life of the aircraft.

c/ Supplied by the Navy, except for A-7X; includes personnel.

d/ Covering operation of active aircraft and training aircraft, plus procurement.

e/ Based on manufacturer's comparison of A-7E and A-7X service hours.

cost that includes attrition aircraft for the full service life, and then scaling that total cost by the ratio of 15 years to the full service life.

When looked at this way, the Navy's preferred option is most costly; the all A-6E option and the re-engined A-7 option are about equal in cost; and the current force option is the least costly.

Five-Year Procurement Costs. While the differences in long-run costs could be substantial, over the next five years differences would be minimal. Accordingly, no estimates are presented.

Meaningful five-year costs would be difficult to define for the Navy's preferred option. The F/A-18 aircraft for the attack squadrons would be produced concurrently with other F/A-18 aircraft and would be indistinguishable from the others in the absence of a list specifying in advance the assignment of individual units. With such a breakdown, costs could be listed by year. While this could be viewed as a true accounting of the costs, it is not a meaningful one for comparing options, since it is not a measure of the costs that would be avoided were this option not chosen. These latter costs, which are shown in Table 6, are obtained by eliminating aircraft from the end of the program.

If another airplane is chosen in place of the F/A-18 as the Navy's replacement for the A-7E, one of three basic strategies could be followed in procuring it. The first would be to begin procurement as soon as possible--that is, during the 1980s concurrently with the F/A-18s that are being procured for other roles. Assuming the F/A-18 program followed the current production schedule, but ended much earlier than it otherwise would, the defense budget would be increased for several years while both aircraft were in production.

A second strategy would be to divide the procurement dollars that would otherwise fund only the F/A-18 program between the two airplanes, lowering yearly buy rates and stretching out both programs. This would reduce the impact on the budget in any given year, but would force higher unit costs of both aircraft and hence higher total costs. Both of these strategies would, however, introduce the new attack airplane into the fleet at the earliest possible date, probably about 1986. (Since the A-6E is currently in production at a low rate, its introduction could begin somewhat earlier.)

A third strategy would be to delay procurement of the new attack aircraft until the reduced F/A-18 buy was completed. If 673 F/A-18s were procured rather than the 1,366 currently in the program, the F/A-18 buy would be completed about 1987, assuming the currently planned production rate schedule is followed. Procurement of the alternative attack aircraft could begin about 1986, with the first units entering the fleet possibly in 1989. This strategy would avoid unit cost increases associated with stretching out a program.

Of the three strategies, the third has the advantages of not increasing the defense budget over the next five years and of not increasing the cost of the alternatives by stretching out programs. It would also have the lowest cost impact over the next five years. In this case, the four alternatives would show the same yearly costs for 1983 to 1985, a slight difference in 1986, and a real difference only in 1987 and beyond. This approach would, however, delay the modernization of the Navy's attack force. The new A-7Es, A-7Xs, or A-6Es would begin entering the fleet about 1988, and the last units would reach the fleet about 1993. By contrast, under the current procurement program, the F/A-18 could enter attack squadrons in 1983 or 1984, and the last units would probably be available by about 1990.

Summary of Attack Aircraft Options

The primary measure of the effectiveness of an attack force is the number of pounds of ordnance it can deliver to a target area during an operating period. Other important considerations are how survivable it is in a hostile environment and how reliable and maintainable the aircraft are, since these factors affect the long-term capacity of the force for ordnance delivery.

Navy Preferred Force. The Navy's preferred force would have a capacity to deliver bombs (measured in pounds delivered in a day) about 20 percent greater than that of the current force, at ranges up to 500 nautical miles from the carrier. 9/ This advantage takes into account superior reliability and maintainability resulting in an initial availability rate one-fourth again as great as those of the A-6E or A-7E. The Navy has operated at these ranges in the past. There is a strong incentive to continue to do so since, regardless of the composition of the attack force, the number of pounds of bombs delivered decreases rapidly as the range of the target from the carrier increases.

Greater stand-off ranges may, however, be required as Soviet capabilities improve, especially in land-based aircraft and missile-equipped coastal craft. In particular, attacks on heavily defended Soviet naval facilities can be expected to encounter significant resistance the closer they get. 10/ Should the Navy

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9/ Much of the advantage would be subject to constraints imposed by the rate at which bombs can be loaded on aircraft.

10/ The Navy has argued that by such attacks it could attempt to deny Soviet forces the ability to put to sea in order to harass the sea lanes.

be forced to operate at long ranges, its preferred force would be less capable than the current force. In particular, beyond 800 miles the F/A-18s would have no capability at all without refueling, so that only the A-6Es in the force could deliver ordnance. At these ranges, the Navy's preferred force would be about 60 percent as capable as the current force.

To the extent that F/A-18 wartime attrition, failure, and repair rates proved better than those of the other alternatives, the capability of the Navy's preferred force would be progressively enhanced relative to the others as the length of an engagement increased. This could be the dominating consideration if the differences were large enough and the engagement long enough. The advantage will be of little value, however, if operations are conducted at long ranges where the F/A-18s cannot operate.

The Navy's preferred force has the added advantage that F/A-18s can be flown as fighters. If they were used to escort an attack, they could free F-14s for fleet air defense; alternatively, they could augment F-14s in fleet air defense.

A-7E Current Force. The A-7E option would continue the current attack force of A-6Es and A-7Es by replacing the A-7Es as they retire with new A-7Es. In February 1982, the Chief of Naval Operations called the A-6E and A-7E "the most capable attack aircraft in the world today, night and all-weather included." 11/ The Navy's concern is that the relatively sluggish A-7E would be subject to unacceptable losses from modern Soviet fighters. This option would cost $4.5 billion to $7.8 billion less than the Navy's preferred option.

Re-engined A-7 Force. The re-engined A-7 option provides a somewhat different approach to the vulnerability problem. The A-7X is a design by Vought Corporation, which manufactures the A-7E. It would re-engine the A-7E to make it supersonic and give it other aerodynamic characteristics, especially thrust-to-weight ratio, somewhat similar to those of the F/A-18. Doing so would, in Vought's view, provide an aircraft about as survivable in a hostile environment as the F/A-18. Moreover, buying the A-7X rather than the F/A-18 would save $1.8 billion to $5.1 billion. However, while the other alternative forces are composed of

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11/ Statement to the House Committee on Armed Services, February 8, 1982.

existing aircraft, the A-7X exists on paper only, although it is a marriage of an existing airframe and an existing engine.

At target ranges of less than 400 nautical miles, the re-engined A-7 option would be about 10 percent less capable than the Navy's preferred option. At longer ranges, it would be up to 2.3 times more capable. Compared with the current force, it would be about 15 percent more capable at all ranges.

All A-6E Force. The all A-6E force would provide the air wings with a homogeneous force of aircraft able to carry much greater payloads to longer ranges than any light-attack aircraft, and able to attack targets obscured by weather or darkness. Since the A-6E is much larger than the A-7E, only ten are in each squadron. The all A-6E force would be more capable than the Navy's preferred force at ranges beyond 300 nautical miles, and slightly less capable at shorter ranges. Beyond 800 nautical miles, it would be three times as capable as the Navy's preferred option, twice as capable as the current force. Procuring the all A-6E force would not, however, solve the vulnerability problem.

The procurement cost of this alternative could be as much as $4.5 billion less than the Navy's preferred alternative, or could be slightly higher. The 15-year life-cycle costs would be lower. This range of costs arises primarily from the application of two different methodologies to estimate the unit cost at yearly procurement rates about ten times those of recent years. Several estimates using one methodology are clustered near the lower overall cost, while several others are clustered near the higher estimates.

Delivery Schedules. If the Navy's preferred force is procured, attack aircraft deliveries could begin in 1983 or 1984 and be completed in the early 1990s. If another option is chosen, delivery within the same span would require increasing budgets in the next few years. Otherwise, deliveries would begin about 1988 or 1989 and end in the mid-1990s. If the F/A-18 is procured as the Navy's fighter rather than the F-14, money could be available to fund an attack aircraft beginning in 1983 or 1984.

ALTERNATIVE FIGHTER AIRCRAFT

The Navy intends to meet its requirements for ten additional fighter squadrons--four to equip the two expansion wings and six to replace the remaining F-4s--by purchasing more F-14s. Earlier the Navy had planned to use the F/A-18 to fill out its fighter force. Substantial amounts could be saved by returning to this earlier Navy plan.

To do so would mean adding less capable fighters to the remainder of the fleet. In the most important mission--that of defending the carrier from incoming missiles--the F-14 is acknowledged to be superior. But the F/A-18 would be much less costly, both over the next five years and in the long run, and it would be the equal of the F-14 in battle with enemy fighters.

Fighter Capabilities

Navy fighters fly two major missions: fleet air defense, and the escort of attack aircraft. The latter mission involves air combat with enemy fighters. The F-14 and F/A-18 appear to be reasonably similar in those attributes affecting air combat. Some analysts believe that the greater maneuverability and smaller size of the F/A-18 may even make it superior to the F-14 against enemy fighters. 12/

The F-14, with its Phoenix missile, was designed to intercept enemy aircraft in fleet air defense. In this it is superior in several ways to the F/A-18. In fleet air defense, a fighter is vectored toward an enemy aircraft that is traveling in the direction of the carrier battle group. The fighter attempts to engage the enemy bomber before it can launch a missile at a ship. 13/ The success of the intercept is critically dependent upon the time required from detection of the incoming bomber (usually by an E-2 airborne early-warning aircraft) until the fighter's weapons destroy it. More than one enemy aircraft would be likely to attack a carrier, and several interceptors would be involved

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12/ Congressional Research Service, Fighter Aircraft Program: F/A-18, Issue Brief 78087 (March 1981); Congressional Research Service, Fighter Aircraft Program: F-14, Issue Brief 76056 (March 1981, and Congressional Research Service, The F/A-18 Hornet: Background Analysis of the Navy/Marine Corps F/A-18 Fighter/Attack Aircraft Program, Report 78-224-F (December 1978).

13/ Typically at about 100 nautical miles from the carrier. See Jane's Weapon Systems, 1980-81.

in the defense. The F-14 and F/A-18 are roughly equivalent in rate of acceleration, but the F-14 has a substantial advantage in maximum speed. 14/ Moreover, the F-14 carries the Phoenix missile, which can be fired at a range of 50 nautical miles against up to six targets simultaneously, or at 100 nautical miles against a single target. The F/A-18's Sparrow missile has a range of about 25 nautical miles against a single target. 15/ In addition, the AWG-9 radar on the F-14 has an advertised range of 170 nautical miles against bombers, allowing the operator time to select targets and assign missiles to them before reaching the launch point. 16/ The F/A-18 radar has a much shorter range. Finally, the ability to engage multiple targets at longer range allows each F-14 to cover a wider attack corridor, reducing the number of interceptors required to cover an attack along several axes simultaneously.

The long-range capability of the F-14 would be very useful in certain circumstances--for example, on carriers operating close to highly defended areas within the Soviet Union (such as Murmansk or Vladivostok), where large numbers of capable bombers would pose a continuing threat over an extended period of time. This sort of threat might, however, tax or even overwhelm several squadrons of F-14s, and exhaust their supplies of Phoenix missiles in short order.

On the other hand, the F/A-18, carrying the Sparrow F and M models and perhaps a new medium-range missile in the late 1980s or early 1990s, will have more capability in fleet air defense than the F-4 now has. Also, the lower capability of the F/A-18 in fleet air defense relative to the F-14 may not always be critical. The F-14 is designed to deal with the most demanding air threats, especially the Soviet Backfire bomber. Using the F/A-18 to fill out the fighter force would leave five carriers with a reduced capability in this respect, although they would still be very capable against lesser threats. Indeed, if the Navy

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14/ The F-14's maximum speed is 2.4 Mach compared with 1.8 Mach for the F/A-18; see Congressional Research Service, Fleet Air Defense: A Naval Problem, Report 79-259F (September 1979).

15/ Congressional Research Service, F/A-18 Hornet.

16/ Congressional Research Service, Fleet Air Defense.

was fighting in an area far from Soviet bases, or against a much less capable foe, the F/A-18 with Sparrow and Sidewinder missiles would have substantial capability.

Then, too, operating policies and distribution of aircraft could be instituted that would minimize the effect of the degradation in fleet air defense capability brought about by use of the F/A-18. Carriers, which often operate in pairs, could be teamed so that one always had F-14s. Alternatively, the Navy could distribute F-14s so that every carrier had at least one squadron. While either alternative would provide all battle groups some F-14 capability against a threat that included some of the most capable Soviet aircraft, it would not suffice against relatively large numbers of them. The overall capability of each battle group and of the entire Navy to perform fleet air defense, as measured in F-14 flight hours per month, would be degraded.

Another advantage of the F/A-18 is that when assigned to fighter squadrons it could be used to augment attack forces. A carrier with two F/A-18 fighter squadrons would have 24 more aircraft capable of dropping bombs than other carriers would have. This would mean a relative improvement in the capacity to deliver bombs to a target area--an improvement of up to 75 percent depending on the attack force (see Figure 4).

Costs

Buying F/A-18 fighters to meet remaining fleet demands would be substantially less costly than buying F-14s. The long-run procurement cost of buying enough F-14s to equip ten squadrons would be $11.2 billion. Adding 248 F/A-18s to the end of the present F/A-18 program would cost $4.2 billion, about one-third as much. (If the F/A-18 was not procured as the replacement for the A-7E, then the total buy of F/A-18s would be smaller and the unit cost of the 248 aircraft would be higher. The cost would then be $4.4 billion rather than $4.2 billion.)

Costs of owning and operating the aircraft (life-cycle costs) are not evaluated in this report. But since the two aircraft have equal service lives of 15 years, the procurement costs appropriate to a calculation of life-cycle costs are those shown here. Over the 15-year period, the F/A-18 force would cost about $1 billion less to operate.

Figure 4.

Range of Improvement in Bomb Delivery Capacity from Adding 24 F/A-18s to a Carrier Air Wing, at Various Distances to Target

Procuring the F/A-18 for these ten squadrons would not only reduce long-run costs, but would also save a total of $5.8 billion over the next five years. This is because F-14 procurement would be terminated in 1983, but procurement of the F/A-18 over the five years would not increase above currently planned levels because the program is already at efficient procurement levels. Thus, while $5.8 billion would be avoided in 1983-1987, the added cost of the extra F/A-18s would not be incurred until after the five-year period. This also means that the Navy would procure 142 fewer fighter aircraft over the next five years under this alternative than it would under its current plan. If the F/A-18 were not bought as the replacement for the A-7E, the five-year savings would be only $1.3 billion, but more fighters would be bought in five years under this option than under the Navy's fighter option.

The Navy would not, however, have to wait until the 1990s to equip its fighter squadrons with F/A-18s under this alternative, since these aircraft could be drawn from any part of the F/A-18 program. Doing so would, of course, delay delivery of F/A-18s for other purposes. At the production rates currently planned, adding 248 F/A-18s at the end of the buy would extend the program by about a year and a half.

In sum, this alternative would equip the remainder of the fleet with F/A-18 fighters at about one-third the cost of equipping them with F-14s. The F/A-18 is clearly less capable in the key role of fleet air defense. But it would have substantial capability in medium-threat areas, such as those in the Persian Gulf. Moreover, only about one-third of the fleet would have F/A-18s under this option; thus, battle groups containing two carriers could always be configured so as to have some F-14 aircraft.

APPENDIXES

APPENDIX A. A CALCULATION OF THE EFFECTIVENESS OF CARRIER-BASED ATTACK FORCES

This appendix describes the methodology used in calculating the total number of pounds of bombs that a carrier-based attack force can carry into a target area during a 12-hour operating day. It combines a calculation of the number of sorties that can be flown to a specific range with the payload that can be carried to that range by each attack aircraft type. The methodology does not take into account the accuracy with which bombs are delivered (although it could be modified to do so in a straightforward manner), or other characteristics that would enter into a judgment of the relative merits of different forces. In this application it has not included in-flight refueling, but that should not affect the relative rankings of aircraft types.

RANGE/PAYLOAD

Data shown in Table A-1 for the F/A-18, A-6E, and A-7E were supplied by the Navy. Data on the A-7X were supplied by

TABLE A-1. RANGE TO WHICH SPECIFIC LOADS CAN BE CARRIED BY AIRCRAFT FLYING A HIGH-LOW-HIGH MISSION PROFILE (In nautical miles)

Load a/	F/A-18	A-6E	A-7E	A-7X
4 Mk-83	706	1,000	793	880
6 Mk-83	630	950	635	767
9 Mk-83	495	775	435	
12 Mk-83	359	600	200	

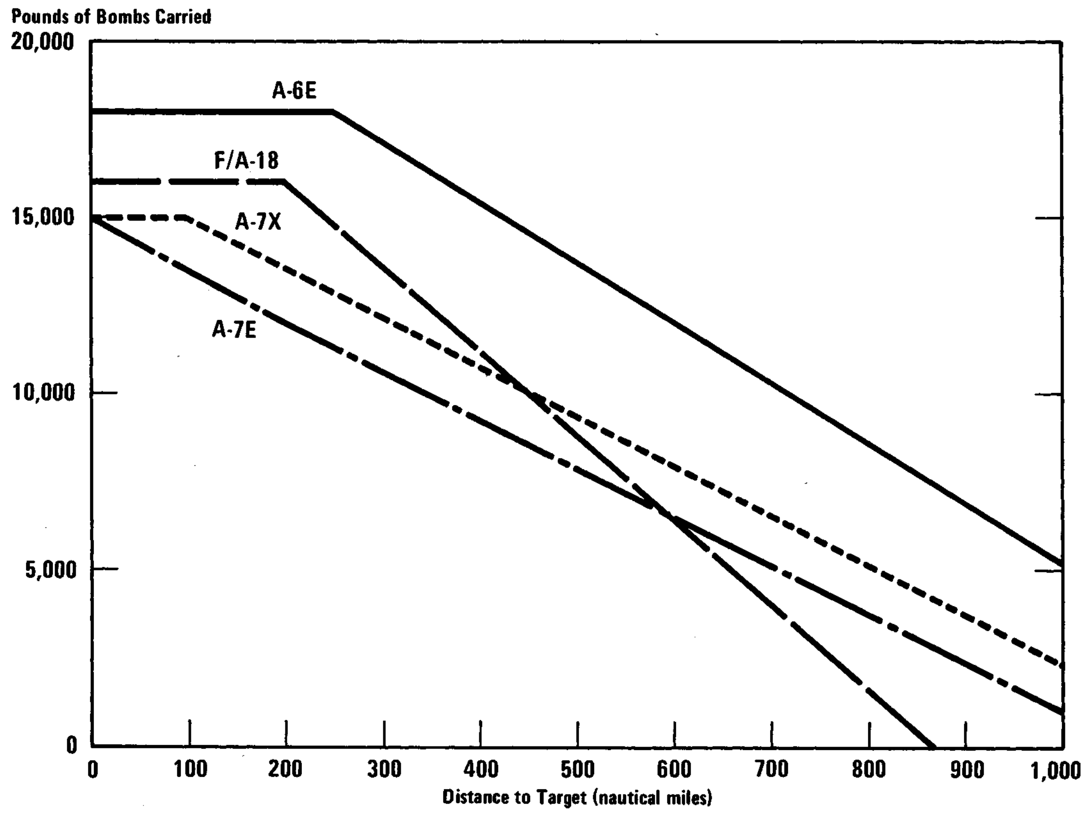
NOTE: External fuel as needed, external tanks dropped when empty. Low leg: five minutes at maximum power without afterburner.

a/ The Mk-83 is a 1,000 pound bomb.

Vought Corporation, which manufactures the A-7E and has defined the A-7X. The data along with maximum payloads obtained from Jane's All the World's Aircraft, 1980-81 were used to produce Figure A-1. The data point for the A-6E carrying four Mk-83 bombs appears somewhat inconsistent with the rest of the data, and was discarded. For the purpose of this analysis, it was assumed that a payload could take on any value between zero and the maximum. In reality, this is not true as bombs come in discrete sizes, and limitations on the numbers that can be carried dictate which payloads are possible. Taking this into account would not alter the trends observed in the calculation; it would simply yield less regular curves with more "wiggles."

Figure A-1.

Range/Payload Comparison of Four Attack Aircraft Forces



NOTE: Hi-Lo-Hi mission profile, no refueling, external fuel as needed, empty tanks dropped.

SORTIE GENERATOR

This part of the calculation draws heavily from the methodology and data developed in the Center for Naval Analyses (CNA) study CNS 1110. 1/ A carrier is assumed to conduct flight operations for 12 hours, and then cease operations. Extension of operations for about one hour to allow recovery of aircraft launched earlier in the day was permitted. Individual deck cycles are either 1.75 hours or 2 hours, and are of constant length throughout the day. During a cycle aircraft are first recovered (except, of course, during the first cycle), then moved, fueled, armed, and launched. At least five launch slots in each cycle are assumed to be devoted to aircraft other than attack aircraft. Attack aircraft are operated either in single cycles or in multiple cycles (that is, remaining in the air for more than one full cycle and being recovered during the next available recovery period). Cycle length was based upon a round trip at 400 knots plus 30 minutes for miscellaneous activities such as grouping while in the air.

The first step in calculating the number of sorties was to count the number of aircraft available for the first cycle. All available aircraft were assumed launched up to the maximum for the cycle; those not accommodated were assigned to the second launch. Since no aircraft were recovered during the first cycle, two launches were made with a suitable delay between. Aircraft launched at the beginning of the first cycle were recovered at the beginning of the second (if on single cycle), while those launched at the end of the first cycle were recovered at the beginning of the third. Available launches were apportioned among attack aircraft types in proportion to the total number of aircraft of each type available for launch. The number of aircraft available for the first cycle was dictated by overall operational readiness rates as supplied by the Navy:

A-7E	54 percent
A-6E	52 percent
F/A-18	66 percent

A7-X availability was assumed to be the same as A-7E availability. This is consistent with contractor statements.

1/ William B. Buchanan, and others, Sea Based Air Platform Cost/Benefit Study, Center for Naval Analyses (January 1978).

All aircraft returning at the beginning of a cycle and not in need of repair were launched at the end of the cycle, and all aircraft repaired during the day were assigned to the next cycle as they became available. 2/ Following the CNA methodology, it was assumed that in all cases 75 percent of the aircraft returning from a mission could be turned around for the next launch after fueling and arming; the other 25 percent needed repair. The mean time to repair was taken to be about three cycles regardless of aircraft type. It was assumed that one-fourth of those in need of repair needed minor repair only and would be available after missing one cycle. Similarly, one-fourth were assumed irreparable during the 12-hour day. One-fourth were assumed ready for the third cycle following the one in which they were initially not ready, and the other fourth were ready for the fourth cycle following the one in which they were initially not ready. Thus, of those aircraft that returned at the beginning of the second cycle in need of repair, 25 percent would be ready for the third cycle, 25 percent for the fifth cycle, and 25 percent for the sixth cycle; 25 percent were lost for the day. This methodology was also applied to those aircraft that were not mission-capable at the start of the day; of those, 25 percent would be ready for cycle 2, 25 percent for cycle 4, and 25 percent for cycle 5.

After calculating the number of sorties flown during each cycle, the total number of sorties for the day was summed.

2/ A cycle is usually defined as beginning with a launch. The sequence is: launch; recover; move, fuel, and arm; launch; and so on. For convenience, this analysis has defined the cycle as beginning with recovery followed by moving, fueling, and arming aircraft, followed by a launch.

AIRCRAFT REQUIREMENTS FOR ONE CARRIER AIR WING

In addition to the aircraft assigned to the air wings--Primary Aircraft Authorization (PAA) or Unit Equipment (UE) aircraft--others are purchased for Fleet Replenishment Squadrons (FRS), RDT&E, pipeline, and peacetime attrition. The number authorized for FRS is generally a fixed fraction of PAA. These aircraft are used for training. The pipeline authorization is a fixed fraction of PAA plus FRS. Pipeline includes aircraft that are being repaired, along with others that have been repaired and will replace those going into repair. The number bought for RDT&E is generally independent of PAA and relatively small, so it will not be included in this accounting.

Table B-1 shows the data for calculation of the aircraft required for one air wing. Requirements for S-3A and ASW helicopters (other than PAA) could not be met unless new production is begun. Expansion could result in reductions in PAA of these types as existing inventories are redistributed. The number required is calculated from the expression N = PAA x (buy factor), where

$$\text{Buy factor} = \left(1 + \frac{\text{FRS}}{100}\right)\left(1 + \frac{\text{Pipeline}}{100} + 15 \times \frac{\text{Attrition}}{100}\right)$$

A 15-year buy factor is used here. Fifteen years is the service life of the F-14 and F/A-18, and less than the service life of the other aircraft. Buying N will provide enough aircraft to establish the air wing and replace attrition for 15 years. However, the value of the aircraft remaining at the end of 15 years will vary with aircraft type since they all have different service lives.

AIRCRAFT UNIT PROCUREMENT COSTS

Two alternative costs will be generated for the air wing shown above. The first will be based on the assumption that no

TABLE B-1. AIRCRAFT REQUIREMENTS FOR ONE CARRIER AIR WING

Aircraft	PAA	FRS (percent of PAA)	Pipeline (percent of PAA + FRS)	Yearly Attrition (percent of PAA + FRS)	15-Year Buy Factor
A-6E	10	25	29	2.5	2.08
F/A-18	24	25	12	3.5	2.06
F-14	24	25	18	3.6	2.15
E-2C	4	25	26	1.5	1.86
EA-6B	4	25	20	4.4	2.33
KA-6D	4	4	26	4.0	1.93
S-3A	10	25	12	1.3	1.64
SH-60	6	25	6	3.0	1.89

PAA: Aircraft assigned to the air wing.

FRS: Aircraft in Fleet Replenishment Squadrons (for training).

Pipeline: Aircraft in the repair pipeline.

$$\text{Buy Factor} = \left(1 + \frac{\text{FRS}}{100}\right)\left(1 + \frac{\text{Pipeline}}{100} + 15 \times \frac{\text{Attrition}}{100}\right).$$

new ASW aircraft are procured. The second will assume that the S-3 line is reopened, and that the SH-60 helicopter is procured as a carrier-based ASW helicopter. The SH-60B is the Navy's LAMPS MkIII ASW helicopter for use on surface combatants (cruisers, destroyers, and frigates). Table B-2 shows the unit costs that will be used in the analysis.

TABLE B-2. AIRCRAFT UNIT COSTS (In millions of 1983 dollars)

Aircraft	Unit Cost	Comments
A-6E	26.7	Unit cost at 12 per year. Continued procurement at 12 per year assumed. Current budget buys 12 per year, except 8 in fiscal year 1983 and 8 in fiscal year 1984 at $33.83 million per unit.
F/A-18	17.2	Average unit cost of last 665 aircraft. Average cost for full program is over $20 million.
F-14	43.32	Unit cost at 30 per year. Continued procurement at 30 per year assumed. Current budget buys 30 per year, except 24 in fiscal year 1983. 1983 unit cost is $48.22 million.
E-2C	53.8	Unit cost at six per year. Continued procurement at six per year assumed.
EA-6B	54.7	Unit cost at six per year. Continued procurement at six per year assumed.
KA-6D	28.7	$2 million conversion of existing A-6E plus replacement with a new A-6E. Since older airplanes are converted, this somewhat overstates the cost.
S-3A	43.4	Based on Navy and manufacturer estimates.
SH-60	13.4	Add-on buy at highest production rate.

SOURCES: Department of Defense budget for fiscal year 1983, except for the F/A-18 which is taken from the December 1981 Selected Acquisition Report.

PROCUREMENT COST OF ONE CARRIER AIR WING

Table B-3 shows the costs of procuring one full carrier air wing, including FRS and pipeline aircraft, but excluding attrition aircraft.

In planning a program, the most economical approach is to buy all aircraft, including those for anticipated attrition, at high production rates, and then terminate production. For example, according to the program as specified in the December 1981 Selected Acquisition Report, the entire F/A-18 buy will be completed about six years after the beginning of large-scale

TABLE B-3. COST OF PROCURING ONE CARRIER AIR WING (In millions of 1983 dollars)

Aircraft	Number	Unit Cost	Total Cost
A-6E	17	26.7	454
F/A-18	34	17.2	585
F-14	36	43.3	1,559
TARPS a/	3	1.6	4.8
E-2C	7	53.8	377
EA-6B	6	54.7	328
KA-6D	6	28.7	172
Total with no new ASW aircraft			3,480
S-3A	14	43.4	607
SH-60	8	13.4	107
Total with all new aircraft			4,194

a/ Tactical Airborne Reconnaissance Pod System.

TABLE B-4. COST OF AIRCRAFT, INCLUDING ATTRITION AIRCRAFT, FOR ONE CARRIER AIR WING (In millions of 1983 dollars)

Aircraft	Total Aircraft Cost: Including Attrition	Total Aircraft Cost: Without Attrition	Cost of Attrition Aircraft: Total	Cost of Attrition Aircraft: Average per Year
A-6E	555	454	101	6.7
F/A-18	852	585	267	17.8
F-14	2,235	1,559	676	45.1
TARPS a/	4.8	4.8	--	--
E-2C	400	377	23	1.5
EA-6B	510	328	182	12.1
KA-6D	222	172	50	3.3
Total with no new ASW aircraft	4,779	3,480	1,299	86.4
S-3A	712	607	105	7.0
SH-60	152	107	45	3.0
Total with all new aircraft	5,643	4,194	1,449	96.4

a/ Tactical Airborne Reconnaissance Pod System.

introduction into the fleet and will include substantial numbers of aircraft for anticipated attrition. 1/

Table B-4 extends Table B-3 to include the costs of attrition aircraft, including their average yearly costs. It is not

1/ Captain J.S. Weaver, F/A-18 program manager, as reported in Aerospace Daily (July 1, 1981). See Also Admiral T.B. Hayward, CNO, as reported in Sea Power (August 1981).

anticipated, however, that attrition costs will be spread evenly over the years of service.

OPERATIONS, MAINTENANCE, AND MANPOWER COSTS

Table B-5 shows the additional personnel that would be needed to man the squadrons in one air wing. This does not include other personnel on the carrier, or those billets associated with increasing FRS and pipeline inventories. Typical total manning of a Nimitz-class carrier is about 6,300.

Table B-6 lists the direct personnel and operation and maintenance costs for one air wing and the associated FRS expansion.

TABLE B-5. PERSONNEL NEEDED FOR ONE CARRIER AIR WING

Aircraft	Officers	Enlisted
A-6/KA-6	38	271
F/A-18	42	416
F-14	70	508
E-2C	29	141
EA-6B	27	167
S-3A	44	256
ASW helicopter a/	23	157
Wing Staff	10	7
Total	283	1,923

a/ SH-3 assumed.

TABLE B-6. OPERATION COSTS FOR ONE CARRIER AIR WING FOR ONE YEAR (In millions of 1983 dollars)

Aircraft	Personnel	Operation and Maintenance	Total
A-6/KA-6	11	23	34
F/A-18	4	40	44
F-14	6	51	57
E-2C	4	8	12
EA-6B	4	12	16
S-3A	6	21	27
SH-60	4	19	23
Total	39	174	213

COSTS OF FIGHTER AND ATTACK AIRCRAFT ALTERNATIVES

Fighter Alternatives

Table B-7 shows the number of F-14s or F/A-18s that would be required to equip ten squadrons.

The F/A-18s would be added to the end of the 1,366 programmed buy at $17.2 million per unit in 1983 dollars. The total cost would be $4.2 billion. They would be procured in fiscal years 1990 and 1991. If the F/A-18 was not procured as an attack aircraft, 28 fewer F/A-18s would be procured in 1986, which would be the last year of the program. If 248 aircraft for fighters were added to this truncated program, they would be procured in 1986 and 1987 at a total cost of about $4.4 billion.

TABLE B-7. NUMBER OF F-14s OR F/A-18s REQUIRED FOR TEN SQUADRONS

Aircraft	Number per Squadron	15-Year Buy Factor a/	Total
F-14	12	2.15	258
F/A-18	12	2.06	248

a/ From Table B-1.

The F-14s are assumed to be procured according to the schedule shown in Table B-8. At an average unit cost of $43.32 million, they would cost $11.2 billion.

TABLE B-8. PROCUREMENT SCHEDULE FOR TEN SQUADRONS OF F-14s

Fiscal Year	Number Procured	Cumulative Total for Ten Squadrons	Cost (millions of 1983 dollars)
1983	24 a/	12	579
1984	30	42	1,300
1985	30	72	1,300
1986	30	102	1,300
1987	30	132	1,300
1988	30	162	1,300
1989	30	192	1,300
1990	30	222	1,300
1991	36	258	1,560

a/ 12 aircraft procured in 1983 complete the inventory for the 18 existing squadrons.

Savings from buying the F/A-18 rather than the F-14 would be as shown in Table B-9.

TABLE B-9. SAVINGS ARISING FROM BUYING TEN SQUADRONS OF F/A-18s RATHER THAN TEN SQUADRONS OF F-14s (In millions of 1983 dollars)

	F/A-18 Is Navy's Light-Attack Aircraft			F/A-18 Is Not Navy's Light-Attack Aircraft		
Fiscal Year	Cost Avoided By Not Buying the F-14 a/	Cost of F/A-18	Net Savings	Cost Avoided By Not Buying the F-14 a/	Cost of F/A-18	Net Savings
1983	579	--	579	579	--	579
1984	1,300	--	1,300	1,300	--	1,300
1985	1,300	--	1,300	1,300	--	1,300
1986	1,300	--	1,300	1,300	(684)	616
1987	1,300	--	1,300	1,300	(3,784)	(2,484)
1988	1,300	--	1,300	1,300	--	1,300
1989	1,300	--	1,300	1,300	--	1,300
1990	1,300	(3,819)	(2,519)	1,300	--	1,300
1991	1,560	(448)	1,112	1,560	--	1,560

a/ Table B-8 last column.

Attack Alternatives

Cost of the F/A-18. Using the 15-year buy factor, 693 F/A-18s would be needed for 28 squadrons. If these were taken off the end of the program given in the December 1981 Selected Acquisition Report, they would be the last 657 (the total for the last three years of the program, 1988-1990) at $17.2 million per unit plus 36 from the preceding year at $23.5 per unit, for a total cost of $12.1 billion. A disproportionate amount of the costs of support equipment appear early in the F/A-18 program. If the procurement of support was redistributed more evenly throughout the program, the cost of the last 693 would rise to about $13.3 billion.

Cost of the A-6E. Twenty-eight squadrons of ten aircraft each would require 583 A-6Es. These would be procured according to the profile shown in Table B-10.

Several methodologies were employed to estimate the cost of procuring A-6Es at these high yearly rates. The calculated total costs for 583 aircraft spanned the range of $8.8 billion to $12.5 billion in 1983 dollars.

The procurement profile shown in Table B-10 requires a change in the rate of A-6E production from the 12 per year that has prevailed in recent years (the Administration has asked for 8 per year in fiscal years 1983 and 1984) to 96 per year. Estimating unit costs at such an enormous change in procurement rate involves considerable speculation, since few data are available upon which to base such projections.

TABLE B-10. A-6E PROCUREMENT SCHEDULE

Fiscal Year	Total Number Procured a/	Number Procured for New Squadrons
1986	24	12
1987	56	44
1988	84	72
1989	96	84
1990	96	84
1991	96	84
1992	96	84
1993	96	84
1994	47	35
Total	691	583

a/ Includes 12 per year procured regardless of which light attack option is chosen.

Two models of the behavior of unit cost with yearly rate changes are used in the Defense Department. One is of the form: 2/

$$F = 0.162 \left[\frac{\text{New Rate}}{\text{Old Rate}}\right]^{-1.669} + 0.838$$

F is the factor used to multiply the old unit cost to get the new unit cost.

The specific numbers in the equation were obtained from aggregated data collected on several airplanes, with a stated range of validity from a 17 percent reduction in buy rate to an 85 percent increase. Clearly, an eightfold increase in buy rate is far beyond the stated region of validity of the model. Some analysts maintain that the model ought not to be applied to the rate of production of the A-6E only, but to combined rates of production of all the aircraft produced by the manufacturer (Grumman Corporation), and furthermore should be applied to all the main systems of the airplane individually, to allow for the different business bases of the different manufacturers of the airframe, engine, and so on. While this would bring the calculation close to the region of validity of the model (Grumman now produces 50 to 60 aircraft per year), it would introduce even more speculation into the modeling process: What will Grumman's business base be in 1990?

The model raises several other problems:

- It predicts that unit cost can never be reduced by more than 16.2 percent.
- It appears to be incapable of explaining the change in unit cost in the A-6E between fiscal years 1982 and 1983.
- It is not self-consistent in the sense that if it is used to calculate the cost at rate 2 from the cost at rate 1, it will not yield the proper cost for rate 1 when applied once again.

2/ Commander Steve J. Balut, "Three Views of the Impact of Production Rates Changes: I. Redistributing Fixed Overhead Costs," Concepts: The Journal of Defense Systems Acquisition Management, vol. 4 (Spring 1981), pp. 63-76.

Despite these shortcomings, the model has proved useful within the Defense Department. Applying it to the case under consideration using different sets of assumptions yields costs for the additional A-6Es of $11.2 billion to $12.5 billion.

A second model developed within the Defense Department is of the form: 3/

$$\text{Cost} = (\text{Constant})(\text{Rate})^{x}$$

or, put in terms consistent with the other model:

$$F = \left[\frac{\text{New Rate}}{\text{Old Rate}}\right]^{x}$$

In this model, the driving factor x must somehow be determined. Large aggregations of data from many different types of systems resulted in a value of $x = -0.1844$. Applying this directly to the program shown in Table B-10, beginning with a unit cost of $26.7 million--the 1982 cost (in 1983 dollars) at 12 per year--yields a total cost of $10.0 billion, after subtracting a steady buy of 12 per year as was done using the other model. Another, more sophisticated application of this model using different sets of assumptions--including some supplied by the manufacturer--yields total costs of $8.8 billion to $9.6 billion. 4/

Cost of the A-7E. Using a training squadron fraction of 25 percent, a pipeline fraction of 14 percent, and 3.5 percent yearly attrition, 700 A-7Es would be needed for 28 squadrons. Applying different methodologies to calculate the unit cost, the total cost for 700 A-7Es would fall in the range of $5.5 billion to $7.6 billion in 1983 dollars. They would be procured in fiscal years 1986-1992.

3/ See John C. Bemis, "Three Views of the Impact of Production Rate Changes: III. A Model for Examining the Cost Implications of Production Rate," Concepts: The Journal of Defense Systems Acquisition Management, vol. 4 (Spring 1981), pp. 84-94.

4/ These other sets of assumptions include a learning curve, and different applications of the rate model to different components.

Cost of the A-7X. It was assumed that 700 A-7Xs would also be needed. These aircraft would cost $8.2 billion to $10.3 billion in 1983 dollars. They are procured in fiscal years 1986-1993.

Life-Cycle Costs. These calculations of procurement costs ignored differences in costs of operation among the different aircraft, and differences in their service lives. These differences are captured by using a 15-year buy factor that includes only the portion of the service life used in 15 years, plus the cost of 15 years' operation. The equation is:

$$\text{Buy factor} = \left(1 + \frac{\text{FRS}}{100}\right) \times$$

$$\left(1 + \frac{\text{pipeline}}{100} + \text{life} \times \frac{\text{attrition}}{100}\right) \times \left(15/\text{life}\right)$$

The fifteen-year total costs are tabulated in Table B-11.

Summary. Table B-12 compares the alternatives in procurement and 15-year life-cycle costs.

TABLE B-11. FIFTEEN-YEAR TOTAL COST COMPARISON OF ATTACK AIRCRAFT ALTERNATIVES

Option	Aircraft	Service Life (years)	Buy Factor	Average Unit Cost (in millions of 1983 dollars)	Procurement (in billions of 1983 dollars)	Yearly Operation (in millions of 1983 dollars per aircraft) a/	Total 15-Year Costs (in billion of 1983 dollars) b/
Navy Preferred	F/A-18	15	2.06	17.5-19.3	12.1-13.3	2.22	26.1-27.3
Current Force	A-7E	17	1.91	7.9-10.9	5.1-7.0	1.74	16.1-18.0
Re-engined A-7	A-7X	13 c/	2.30	12.0-14.7	8.5-11.4	1.91 d/	20.5-23.4
All A-6E	A-6E	23	1.51	15.1-21.4	6.4-9.0	2.86	21.4-24.1

a/ Supplied by the Navy, except A-7X; includes personnel.

b/ Fifteen years' operation of active aircraft and training aircraft, plus procurement.

c/ Based on manufacturer's comparison of A-7E and A-7X service hours.

d/ Ten percent greater than for the A-7E.

TABLE B-12. COST COMPARISON OF ATTACK AIRCRAFT ALTERNATIVES
(In billions of 1983 dollars)

Option	Aircraft	Procurement		15-Year Life Cycle	
		Cost	Savings Over F/A-18	Total Cost	Savings Over F/A-18
Navy Preferred	F/A-18	12.1-13.3	--	26.1-27.3	--
Current Force	A-7E	5.5-7.6	4.5-7.8	16.1-18.0	8.1-11.2
Re-engined A-7s	A-7X	8.2-10.3	1.8-5.1	20.5-23.4	2.7-6.8
All A-6Es	A-6E	8.8-12.5	(0.4)-4.5 a/	21.4-24.1	2.0-5.9

a/ Parentheses indicate more costly than F/A-18.

APPENDIX C. EXPANSION OF THE CARRIER FORCE AT CURRENT AIRCRAFT PRODUCTION RATES

Under the current shipbuilding schedule, one new air wing will be required in 1983 and a second in 1986 or 1987. These schedules can be met with the annual production rates that have prevailed in recent years: 30 F-14s, 12 A-6Es, 6 EA-6Bs, and 6 E-2Cs. The anticipated F/A-18 production can also support the expansion.

This was demonstrated by analyzing inventory levels, beginning with actual 1981 inventory levels, adding and subtracting new production, anticipated attrition, and aircraft conversions year by year. (Current inventory levels are classified information; this report presents a summary of the numerical analysis and not the actual analysis.)

F-14

A constant production rate of 30 per year can support 20 squadrons by 1983, 22 squadrons by 1985, 24 squadrons by 1988, 26 squadrons by 1991, and 28 squadrons by 1993. The planned reduction of production to 24 for fiscal year 1983 will not affect this schedule. This schedule can probably be accelerated by keeping inactive inventories (i.e. advance attrition) below authorized levels until all squadrons are equipped.

A-6E

Continued production of 12 per year will support the introduction of one squadron in 1983 and one squadron in 1986-1987. This includes an allowance for the conversion of four aircraft per year to the KA-6D. The planned reduction to 8 per year in fiscal years 1983 and 1984 will not affect the Navy's ability to meet this schedule.

KA-6D

The Navy is currently short some KA-6Ds in the pipeline. An average of four conversions per year will support the planned expansion and correct the shortfall.

EA-6B

The Navy is currently short several EA-6B squadrons, and is short in overall Navy and Marine Corps inventory. The shortage in active squadrons is made up by assigning Marine Corps EA-6B detachments to carriers. The current building rate of six per year is sufficient to support the expansion (assuming the continued assignment of Marine Corps detachments and carriers), and eradicate the shortfall by the early 1990s.

E-2C

The Navy still operates E-2B aircraft on some carriers. A buildup rate of 6 E-2Cs per year will support the establishment of one E-2C squadron in 1983, one in 1986-1987, and the elimination of all E-2B aircraft from the inventory by the early 1990s.

S-3A, SH-3, SH-60

The inventories of both the S-3A and the SH-3 contain attrition aircraft that were bought in anticipation of closing the production lines. The expansion can be accommodated either by reducing the number of aircraft per squadron, or by activating some attrition (and pipeline) aircraft, or by some combination of both. 1/ Activating attrition aircraft would result in eventual reduction in numbers per squadron as aircraft are lost and cannot be replaced. In the case of the S-3A, reductions in the number per squadron would occur at the latest at the time of the second expansion wing. SH-3 reductions would begin at about the time of introduction of the second expansion wing. However, the planned production of the carrier variant of the SH-60 beginning in 1986 should make such reductions unnecessary.

F/A-18

In 1980, 25 production aircraft were funded. These, together with 9 that were funded in previous years, should be completed during 1982 and would then be available to form two squadrons for a new wing. Sixty aircraft funded in 1981 would be available soon after. All 1,366 would be funded by the early 1990s.

1/ For example, one S-3A squadron can be created by reducing the number of embarked aircraft from ten to nine.