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THESIS

COST AND OPERATIONAL EFFECTIVENESS ANALYSIS OF ALTERNATIVE FORCE STRUCTURES FOR FULFILLMENT OF THE UNITED STATES MARINE CORPS OPERATIONAL SUPPORT AIRLIFT AND SEARCH AND RESCUE MISSIONS

by

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March 2000

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COST AND OPERATIONAL EFFECTIVENESS ANALYSIS OF ALTERNATIVE FORCE STRUCTURES FOR FULFILLMENT OF THE UNITED STATES MARINE CORPS OPERATIONAL SUPPORT AIRLIFT AND SEARCH AND RESCUE MISSIONS

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ABSTRACT

This thesis provides a preliminary cost and operational effectiveness analysis of alternative force structures for the United States Marine Corps operational support airlift and search and rescue missions. The four alternative force structures include C-12s and CH-46Es, C-35s and CH-46Es and HV-609s. Lifecycle cost analysis of the alternative force structures using Crystal Ball forecasting provides a 90% upper confidence level lifecycle cost estimate that identifies a mix of C-35s for operational support airlift and CH-46Es for search and rescue as the least expensive alternative. Operational effectiveness analysis provides a measure of overall utility for each of the four alternative force structures based on five measures of effectiveness. The measures of effectiveness examined are air travel time, total travel time, landing site requirements, range versus time on station, and payload versus range. Analytical hierarchy process rankings indicate that the HV-609 is the preferred alternative considering these measures of effectiveness. Analysis of cost versus operational effectiveness identifies the HV-609 as the most cost and operationally effective alternative for fulfilling the Marine Corps operational support airlift and search and rescue missions.

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I. INTRODUCTION

> The powerful and innovative aircraft that you see here today, the tiltrotors...are going to revolutionize not only our force projection but the entire way that America conceives and sustains its policy of engagement in the decades ahead.
>
> William Cohen, Sept. 8, 1999

A. PURPOSE

This thesis will provide a preliminary cost and operational effectiveness analysis of alternative force structures for the operational support airlift and search and rescue missions. This thesis will also evaluate the possible life cycle costs and benefits of procuring a single platform for two missions.

B. BACKGROUND

As the United States Marine Corps enters the twenty-first century, it is poised to do so undertaking substantial force modernization. The MV-22 tiltrotor will replace the venerable CH-46E and the Advanced Amphibious Assault Vehicle will replace the aging Amphibious Assault Vehicle, enabling the Corps to complete its vision of Over The Horizon warfare. Additional increases in warfighting capability will come from fielding the 5-ton Medium Tactical Vehicle Replacement and the Lightweight Towed Howitzer.

Overlooked in this modernization strategy are the non-tactical assets that play a vital role in the Marine Corps. As a force in readiness, the Corps requires both tactical and non-tactical assets to maintain warfighting capacity. Operational Support Airlift (OSA) aircraft, such as the C-12, provide the Corps' senior warfighters with a degree of flexibility not available through commercial travel in peacetime and wartime. Search and rescue (SAR) helicopters play an important role in Marine Aviation's continued combat preparation. Tenant SAR units ensure a quick response to the warfighter in training and provide the civilian community at large an additional asset in time of need. Both of these missions are performed on the periphery of USMC operations. Neither is high visibility, but both are equally important. Assets for these missions are approaching the end of their service lives and are in need of replacement.

Just as the MV-22 will likely revolutionize vertical lift in warfighting, the tiltrotor has the potential to revolutionize the commercial market for vertical lift requirements. Tiltrotor proponents declare that the distinction between rotary wing missions and fixed wing missions will be transcended by the versatility of the tiltrotor. Traditional ties to a fixed wing infrastructure for fixed wing performance will be replaced with fixed wing performance operating from a helicopter infrastructure. Potential exists for the Marine Corps to be a civil-military leader in advancing tiltrotor technology beyond the battlefield while modernizing two of it's non-tactical assets.

This thesis will serve as a preliminary study into the comparative analysis of cost and operational effectiveness of alternative force structures designed to fulfill the United States Marine Corps operational support airlift and search and rescue missions.

C. RESEARCH QUESTIONS

The primary research question is: What is the comparative cost effectiveness of four alternative force structures consisting of C-12s, C-35s, CH-46Es and HV-609s for the OSA and SAR mission?

The subsidiary research questions are as follows:

1. What are the USMC requirements for regional fixed wing transportation?

2. What are the USMC requirements for land based Search and Rescue?

3. To what extent is the HV-609 capable of conducting both the OSA and SAR missions?

D. SCOPE AND METHODOLOGY

This thesis will compare four alternative force structures designed to accomplish two missions. By analyzing the overall capability of alternative force structures instead of specific mission requirements, a measure of non-tactical asset utility can be assessed. This overall measure of force structure utility will be used as an effectiveness measure in a lifecycle cost effectiveness analysis.

Historical data were obtained to estimate specific mission utilization rates and operating and support costs. Research was conducted to determine aircraft capabilities and suitability for specific missions. Models were constructed to forecast twenty-year life cycle costs for each alternative force structure. Measures of effectiveness were derived to determine force structure capability across both the OSA and SAR missions. Finally, a decision support software program was used to analyze the overall utility of each force structure.

The availability and quality of cost data limit this thesis. The data used are only as good as the originating sources allow it to be. Data from other DoD components was not available and commercial data were considered proprietary. To account for uncertainty in the cost data, cost driver variability was increased and cost models included 90% upper confidence levels for analysis.

Utility analysis in this thesis was conducted subjectively based on a qualitative assessment of measures of effectiveness vice objectively through the use of quantitative assessments.

E. ORGANIZATION OF THE STUDY

Chapter I identifies the focus and purpose of the thesis as well as the primary and secondary research questions.

Chapter II provides the reader with a background of the OSA and SAR requirements. It also provides an overview of current assets and the history of the tiltrotor.

Chapter III presents four alternative force structures and summarizes the characteristics of each aircraft in the various force structures to determine suitability for inclusion in the analysis.

Chapter IV analyzes the life cycle cost of each alternative force structure.

Chapter V analyzes the overall operational effectiveness of each alternative force structure.

Chapter VI presents the conclusions and recommendations of the thesis and provides areas for further research.

F. BENEFITS OF THIS THESIS

While currrent OSA and SAR asset replacements are not scheduled for the immediate future, this study may provide the preliminary foundation for further Chief of Naval Operations, United States Marine Corps Deputy Chief of Staff for Aviation and Naval Air Systems Command exploration of alternative aircraft. This thesis may also aid in analyzing alternatives for the future replacement aircraft for the AH-1 and UH-1, the Joint Replacement Aircraft (JRA), scheduled for 2025.

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II. BACKGROUND

This chapter examines the underlying requirements for two Marine Corps missions: operational support airlift and land-based search and rescue. Assets currently used for these missions and alternative candidate fixed-wing, rotary-wing and tiltrotor aircraft for each mission will then be introduced. Finally, the chapter concludes with a brief history of tiltrotor development.

A. UNITED STATES MARINE CORPS REQUIREMENTS

Nearly every mission that DoD components exercise is documented by a directive or order. This section will examine the requirements that drive both the operational support airlift and search and rescue missions within the United States Marine Corps.

1. Operational Support Airlift

The United States Marine Corps, as well as other DoD components, derive their General Officer and VIP transportation mission from DoD Directive 4500.43, Operational Support Airlift (OSA). This directive defines OSA missions as "movements of high priority passengers and cargo with time, place, or mission sensitive requirements." Further, DoD 4500.43 dictates that DoD components budget for the cost of operating their OSA aircraft and assign and manage OSA aircraft as required to maximize wartime readiness, efficiency, cost effectiveness and peacetime utilization. The OSA aircraft inventory is based on joint wartime readiness requirements of combatant commanders and the military departments. (Ref. 1, pg. 2)

The use of OSA aircraft is likewise delineated in DoD 4500.43. OSA assets are not to be used if commercial travel, including charter service, is reasonably available (defined as within ± 24 hours), unless highly unusual circumstances present clear and present danger, an emergency exists, the use of military air is more cost effective, or compelling operational considerations make commercial transportation unacceptable. Based on these constraints, it can be inferred that cost effectiveness and timeliness in operational considerations drive the peacetime use of OSA assets.

OSA asset requirements are based on wartime requirements. These assets do not have an originating operational requirements document (ORD) which specifies minimum performance parameters. (Ref. 2) An October 1995 Joint Wartime Staff Requirements Study identified two types of OSA aircraft: short-range and long-range. Long range aircraft are those aircraft having a range of 600 nm or greater. Short-range aircraft are therefore defined as those aircraft having a range of less than 600 nm. The joint study also categorized short-range aircraft as aircraft having an average speed of less than 250 kts. (Ref. 3, pg. 2) Further, the United States Transportation Command (USTRANSCOM) defines short-range aircraft as having the capacity of nine or fewer passengers and 1000 lbs or less of cargo. Traditionally, the Marine Corps and other military services have used fixed-wing aircraft for this mission.

2. Search and Rescue

The Marine Corps, as well as other DoD components, derive their SAR requirement from the National Search and Rescue Manual, Volume I: The National Search and Rescue System (Joint Pub 3-50). This manual was prepared under the direction of the Interagency Committee on Search and Rescue (ICSAR), a committee sponsored by the United States Coast Guard (USCG) that includes the following member agencies: Department of Transportation, Department of Defense, Department of Commerce, Federal Emergency Management Agency, Federal Communications Commission, National Aeronautics and Space Administration and the Department of Interior. Joint Pub 3-50 describes the national search and rescue organization and provides consolidated guidance to U.S. federal forces, both civil and military, with civil SAR responsibilities. Appendix A of the National SAR Manual states: "Department of Defense components provide SAR facilities for their own operations. These facilities may be used for civil needs on a not-to-interfere basis with military missions." (Ref. 4, pg. A-1)

Based on this requirement, the USMC maintains a land-based SAR capability at every Marine Corps Air Station (MCAS) that has tenant tactical fixed wing aircraft: MCAS Cherry Point, NC; MCAS Beaufort, SC;

MCAS Yuma, AZ; and MCAS Iwakuni, Japan. The USCG covers MCAS Miramar's SAR requirement under an interagency agreement between the Coast Guard and the Marine Corps. (Ref. 5) The Marine Corps has traditionally used helicopters to fulfill this SAR requirement.

Each SAR unit maintains its own Standard Operating Procedures (SOP) which provide guidelines and limitations on flight operations. A representative SOP from Marine Transport Squadron One (VMR-1) at MCAS Cherry Point provides guidelines that will be used as a surrogate USMC standard for this thesis. In this SOP, over-water flights by single aircraft are limited to 100nm, unless a helicopter capable ship is present for refueling and radio relay. (Ref. 6 pg.42)

B. CURRENT ASSETS

This section will present both the fixed and rotary wing assets currently available in the DoD or the commercial sector for OSA and SAR missions as described in the previous section.

1. Fixed Wing

The USMC currently maintains a fleet of C-12 variant aircraft for non-tactical fixed wing transportation. (Figure 1) The Department of the Navy (DoN) maintains 87 C-12s, of which the USMC has 18 that are almost exclusively used for transporting General and Flag Officers. The Fleet Marine Forces use 14 of these aircraft; the remaining 4 are used by the USMC Reserve (USMCR). These aircraft are operated by USMC personnel but maintained under a commercial contract. No official plans currently exist to replace these aircraft when they reach their scheduled service life, but studies examining replacement options are currently being conducted. (Ref. 7)

Figure 1. C-12 from Ref. 8

The UC-35 is a military version of a civilian executive business jet, the Cessna Citation Ultra Encore. (Figure 2) The United States Army has begun procuring 35 of these aircraft for their OSA fleet. The USMCR has purchased two UC-35s as replacements for its TC-39s and has two more on order. (Ref. 9)

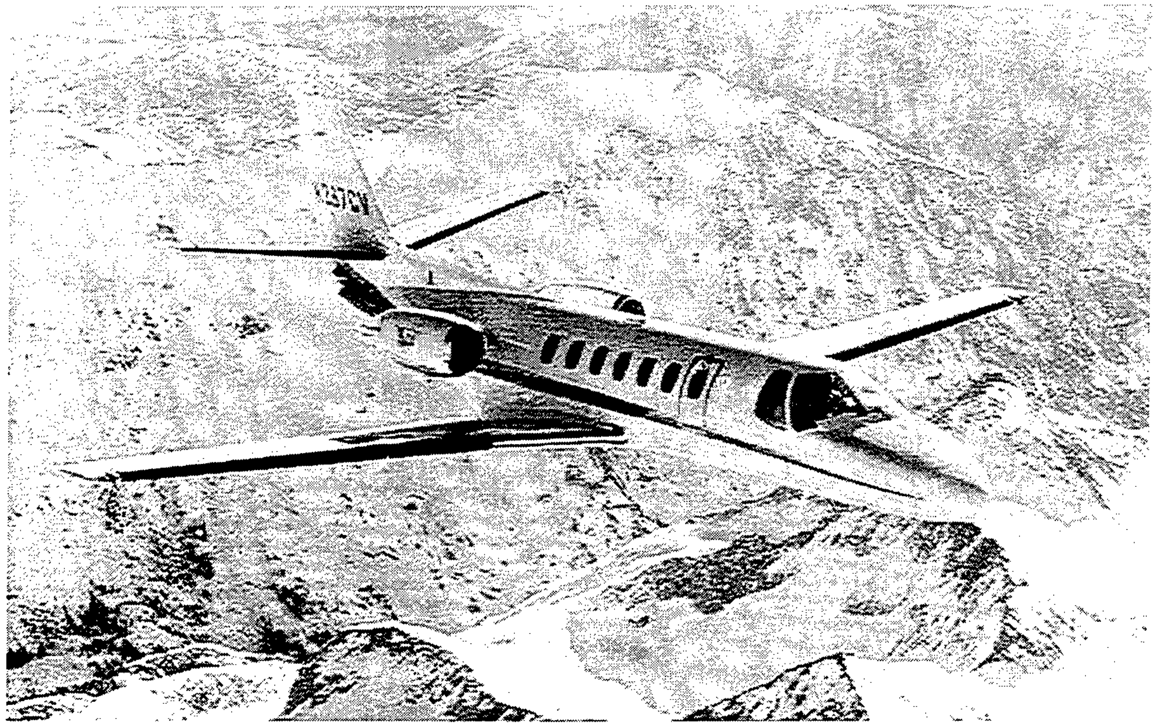

Figure 2. C-35 from Ref. 10

2. Rotary Wing

The United States Marine Corps currently uses the Boeing HH-46D and Bell HH-1N for land-based over-water search and rescue operations at Marine Corps Air Stations that have tenant tactical aircraft squadrons. The HH-46D is presently utilized for the land-based over-water search and rescue mission. A total of nine HH-46D aircraft are assigned to three bases: Cherry Point, Beaufort and Iwakuni. The HH-1N is currently utilized exclusively at Yuma for over-land search and rescue. (Ref. 5)

As the MV-22B becomes operational, HH-46Ds will be replaced by CH-46Es (Figure 3) converted for the SAR mission. (Ref. 11) The HH-1-

Ns currently in use for SAR will be converted to UH-1Ys, but returned to the Fleet Marine Force, not SAR units. Current HQMC plans call for replacing the HH-1N with CH-46Es. (Ref. 5) CH-46Es are currently configured with either original stubwing fuel tanks, each with a capacity of 178 gallons, or extended range stubwing fuel tanks, each having a capacity of 330 gallons. By 2005, when the United States Navy completes its transition to the H-60, the CH-46E will be the USMC's "new" SAR platform.

Figure 3. CH-46E from Ref. 12

C. TILTROTOR HISTORY

The HV-609 tiltrotor aircraft is a candidate aircraft for the OSA and SAR missions. This section will briefly describe the history of tiltrotor development and background of the HV-609.

1. Tiltrotor Concept

The first conceptual tiltrotor design, the British designed Baynes Heliplane, was patented in 1937, but never developed. This tiltrotor looked much like a tiltrotor as they appear today: an airplane with vertical lifting rotors at its wingtips that rotated forward for forward flight. (Ref. 13, pg. 174) Another tiltrotor design, never built, was the German Focke-Achgelis Fa-269. This tiltrotor is unique among tiltrotor designs in that its propeller/rotors were in a pusher configuration. In airplane mode, the propellers pointed aft; in a hover they were below the aircraft. (Ref. 13 pg. 177)

In the United States, the first tiltrotor design came from W. Lawrence LePage. This design was very similar to the Baynes Heliplane and based on the XR-1 helicopter. The XR-1 helicopter was more or less a conventional airplane with rotors mounted at the tip of each wing. These rotors were counter-rotating, negating the need for a directional control tailrotor. In LePage's tiltrotor design, the rotors would tilt forward as the aircraft accelerated, providing thrust as traditional propellers. It was never produced because the size of its rotors and total weight of the aircraft exceeded technological limits in aircraft manufacturing. (Ref. 13, pg.177)

DoD involvement in tiltrotor development began in 1950 with the Air Force's convertiplane project. Desiring a faster observation and reconnaissance platform that was capable of hovering, the Air Force tested three separate designs: the XV-1 from McDonnell Corporation, the XV-2 from Sikorsky Aircraft and the XV-3 from Bell. Of these designs, only the Bell XV-3 was a true tiltrotor. The XV-1 had a pusher prop for forward thrust and the XV-2 used jet propulsion for forward thrust. (Ref. 14, pg. 86).

The XV-3 (Figure 4) design was similar to the LePage tiltrotor. The XV-3 was powered by a single radial reciprocating engine in the aircraft fuselage that drove the propeller/rotors in each wingtip using shafts in the wings. The XV-3 first hovered on August 11, 1955 and made its first successful transition from a hover to forward flight on December 17, 1958. (Ref. 15, pg. 4) Over the next seven years, two XV-3 aircraft logged over 450 hours and made over 100 full conversions from helicopter mode to airplane mode. (Ref. 16, pg. 22)

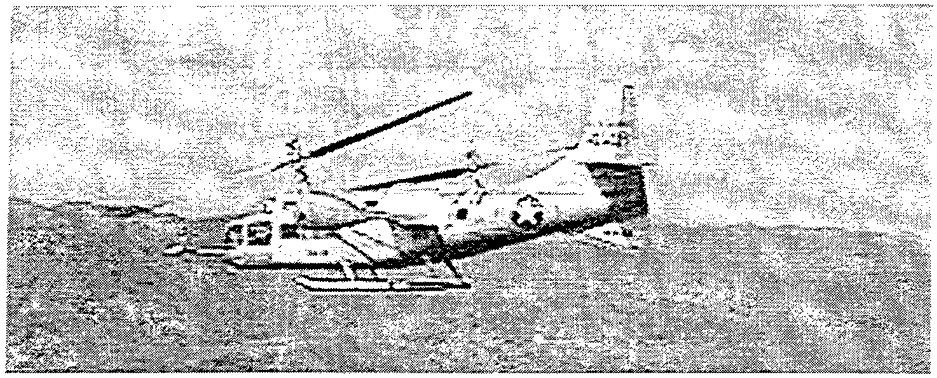

Figure 4. Bell XV-3 from Ref. 17

2. XV-15

Bell Helicopter continued company financed tiltrotor research after the XV-3 program ended. In July 1972, Bell received a joint Army/NASA contract to develop two tiltrotors, designated the XV-15. The XV-15 (Figure 5) was funded as a "proof of concept" or "technology demonstration" aircraft. (Ref. 18)

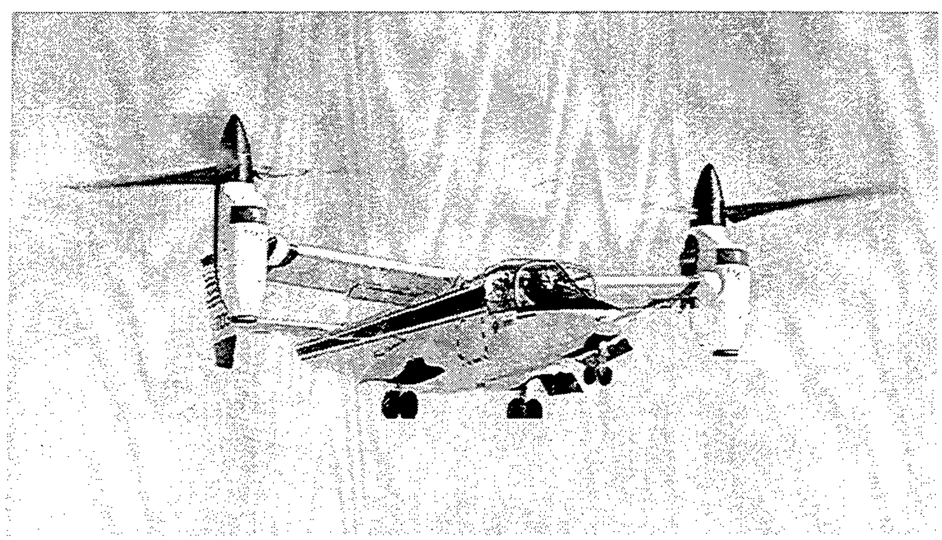

Figure 5. XV-15 from Ref. 18

Unlike the XV-3, the XV-15 was powered by two turbo shaft engines in each wingtip that were connected by a cross shaft. One engine could power both rotors in the event of an engine failure. At a weight of 13,000 lbs, the XV-15 was also significantly heavier than the 4,800 lb XV-3. The first XV-15 flight in helicopter mode occurred in May 1978 and the first full conversion occurred on July 24, 1979. Ultimately, the XV-15 flight envelope was expanded to a speed of nearly 300 kts and an altitude of 21,000 ft. (Ref. 15, pg.) The XV-15 program successfully demonstrated the maturity of tiltrotor technology and was directly responsible for the Joint Services Advanced Vertical Lift Project (JVX). (Ref. 14, pg. 89)

3. V-22

In response to the DoD JVX program, Bell Helicopter Textron and Boeing Helicopters teamed to create the V-22. Dubbed the Osprey by Secretary of the Navy John Lehman, the V-22 (Figure 6) began full-scale development in June 1985 and made its first flight on March 19, 1989. Despite program funding cuts in April 1989 by Secretary of Defense Richard Cheney, the V-22 stayed alive through congressional support. Over the next five years, four separate analyses would show the V-22 to be the most cost and operationally effective replacement to the aging CH-46E. (Ref. 15, pg. 5-9)

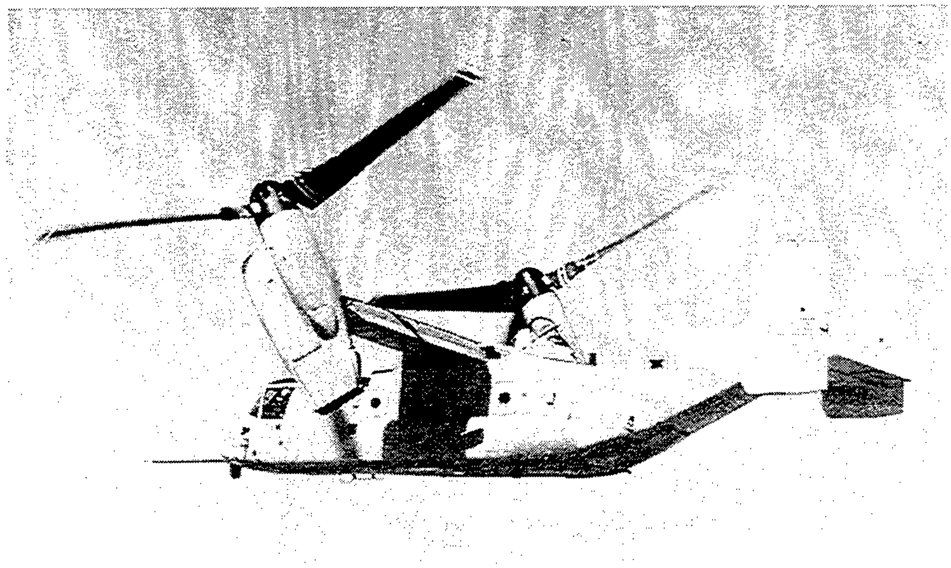

Figure 6. MV-22 from Ref. 19

As of April 8, 1999, the V-22 has met or exceeded all of the Joint Requirements Oversight Committee (JROC) approved key performance parameters. The Osprey has achieved a top speed of 342 kts, an altitude of 25,000 ft and has flown 227 kts while carrying a 10,000 lb external load. (Ref. 20) The Marine Corps plans on buying 360 V-22s over the next two decades to modernize its medium lift helicopter fleet.

4. BA-609/HV-609

The success of the XV-15 and the V-22 has not gone unnoticed in the civilian market. In 1996, Bell Boeing announced plans to design, develop, certify and market a six to nine passenger civilian tiltrotor, the Bell Boeing 609. In 1998, Boeing withdrew from the partnership. Bell subsequently teamed with the Italian company Agusta to produce and market the BA-609 (Figure 7). A full size mock-up was exhibited for the first time at the Paris Airshow in 1997. By November 1998, Bell received more than 70 orders for BA 609 tiltrotors. The HV-609 is a military version of the BA-609. Bell Helicopter Textron, Incorporated (BHTI) is marketing the HV-609 as a multi-mission platform, capable of cargo transportation, executive transportation, and search and rescue operations. The United States Coast Guard is currently considering the HV-609 for search and rescue operations as part of their Deepwater Project. (Ref. 21). The first flight of the BA-609 is scheduled for late 2000 with initial deliveries scheduled for mid 2002.

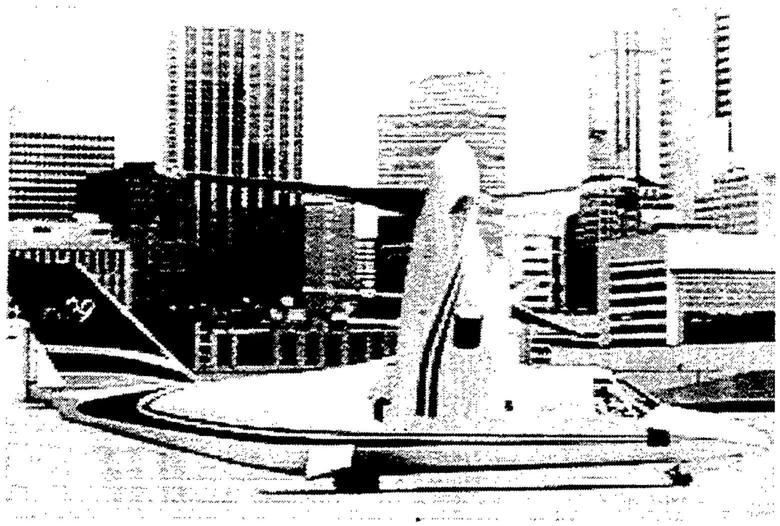

Figure 7. BA-609/HV-609 from Ref. 21

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III. FORCE STRUCTURE ALTERNATIVES AND AIRCRAFT CHARACTERISTICS

This chapter presents four alternative force structures that will be compared for fulfilling the Marine Corps OSA and SAR missions described in the previous chapter. Additionally, the chapter summarizes characteristics of the various aircraft considered for each mission within each alternative force structure. These force structures and aircraft will be compared to determine the suitability of each for the specific mission they will fulfill.

A. ALTERNATIVE FORCE STRUCTURES

This section presents four alternative force structures to fulfill both the USMC's short-range OSA and SAR requirements. Two alternative force structures follow the traditional approach to each mission: fixed wing aircraft for operational support airlift and rotary wing aircraft for search and rescue. The third and fourth alternative force structures offer a technologically innovative approach for both missions: a tiltrotor aircraft.

1. Alternative I: C-12 and CH-46E

This alternative uses C-12s for OSA missions and converted CH-46Es for SAR. Under this alternative, the Marine Corps will purchase new C-12s from Raytheon while continuing to use its existing C-12 fleet, making the repairs and modifications necessary to keep the aircraft airworthy. The current practice of using contract logistic support for maintaining these aircraft is continued in this alternative. A total of 14 C-12s are required to maintain the current USMC FMF force structure. For SAR assets, existing HH-46Ds and HH-1Ns are replaced on a one for one basis with converted CH-46Es. A total of 12 CH-46Es are required to fulfill current SAR requirements, three each at MCAS Cherry Point, MCAS Beaufort, MCAS Yuma and MCAS Iwakuni. SAR assets would continue to be maintenanced by Marines assigned to the SAR units, as is currently the practice.

2. Alternative II: C-35 and CH-46E

This alternative replaces existing C-12 assets on a one for one basis with the C-35. C-12s are continued in use until fully replaced by C-35s. As in Alternative I, necessary repairs are made to maintain the airworthiness of the C-12s until they are completely phased out. Total OSA aircraft numbers remain constant at 14 throughout the transition to the C-35. C-12 and C-35 maintenance would be performed under contract logistic support as is the current practice with the C-12. SAR assets are replaced in the same manner as outlined in Alternative I, ensuring that no gap in SAR capability exists during the transition to the CH-46E. As in Alternative I, SAR asset maintenance would be the responsibility of the SAR units. A total of 14 C-35s and 12 CH-46Es are required in this alternative.

3. Alternative IIIa: HV-609

This alternative uses HV-609 variants to fulfill both OSA and SAR requirements. For OSA requirements, existing C-12 assets are replaced one for one with an executive transport configured HV-609. For SAR requirements, existing HH-46Ds are replaced one for one with SAR configured HV-609s. Contract maintenance for both OSA and SAR assets is used in this alternative because SAR assets are located at air stations that already utilize contract maintenance for OSA aircraft. Having a high degree of commonality in OSA and SAR aircraft provides the flexibility to extend OSA contract maintenance to encompass SAR assets at these locations. A total of 14 OSA configured and 12 SAR configured HV-609s are required for this alternative force structure.

4. Alternative IIIb: HV-609

Like Alternative IIIa, this alternative also uses HV-609 variants to fulfill both OSA and SAR requirements. For OSA requirements, existing C-12 assets are replaced one for one with an executive transport configured HV-609. However, for SAR requirements, two SAR configured HV-609s are exchanged for every three SAR helicopters. Current SAR helicopter age and maintenance complexity drive the requirement to maintain three helicopters to ensure that one is always available. Bell claims that the HV-609 will be more reliable and easier to maintain than a helicopter. Based on that assumption, fewer aircraft would be required to meet availability requirements. According to Bell, all primary and secondary structures in the HV-609, including drive shafts, are, by design, expected to be infinite life components. Additionally, using contract maintenance for both OSA and SAR assets under this alternative force structure, as is done in Alternative IIIa, provides a certain degree of flexibility to ensure that required aircraft availability is achieved and maintained. Figure 8 provides a graphic comparison of asset requirements under each alternative force structure.

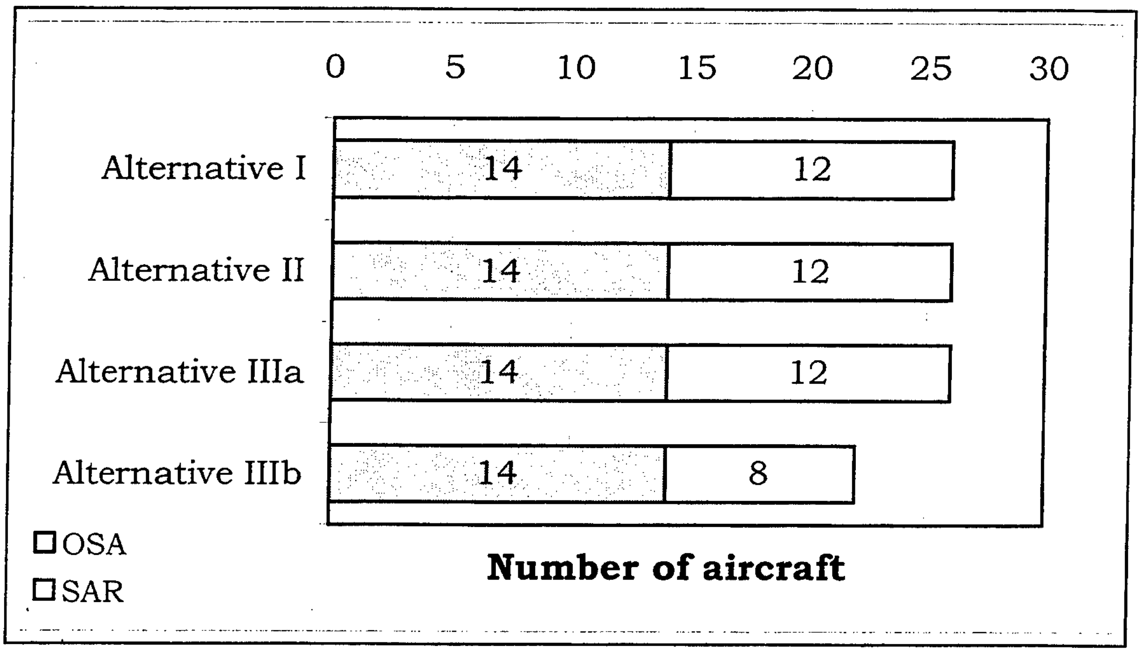

Figure 8. Alternative Force Structure Aircraft Requirements

B. AIRCRAFT CHARACTERISTICS AND CAPABILITIES

This section summarizes the characteristics and capabilities of the C-12, C-35, CH-46E and the projected performance of the HV-609 and discusses the significance of selected characteristics. In the case of the HV-609, the limited information regarding design and performance specifications provided by Bell are treated as reliable and reasonable performance estimates, given the past performance of the XV-15 and present performance of the V-22. Individual aircraft data summaries and three view diagrams are contained in Appendix A. A summary of selected performance characteristics is provided in Table 1.

	UC-12	UC-35	HV-609	CH-46E
Max Cruise speed (kts)	292	431	275	145
Ceiling (ft)	35,000	45,000	25,000	10,000
Max gross wt (lbs)	12,500	16,630	Vertical: 16,000 STOL: 18,000	24,300
Max range (nm)	1,883	2,000	750 w/o aux fuel 1200 w/ aux fuel	350 w/o aux tanks 480 w/ 1 aux tank 570 w/ 2 aux tanks
Payload (lbs)	4,308	6,653	5,500	4,300
Passengers	7-9	7-8	6-9	12-18

Table 1. Aircraft Comparison

1. Cruise Speed

Cruise speed is important in both OSA and SAR missions. Because timeliness in operational considerations is one of the principle drivers in the peacetime use of OSA assets, a higher cruise speed is more desirable.

A higher cruise speed should decrease the length of time passengers spend in the air transiting from one site to another. In SAR missions, a faster cruise speed can literally be the difference between life and death. Survival time in water decreases as water temperature drops. Immersion in water with a temperature between 50°F and 60°F for as little as two hours can result in loss of consciousness due to hypothermia. (Ref. 22, pg. 8-3) Wind chill factors further exacerbate survival conditions. Figure 9 shows the relationship between probability of survival and water temperature.

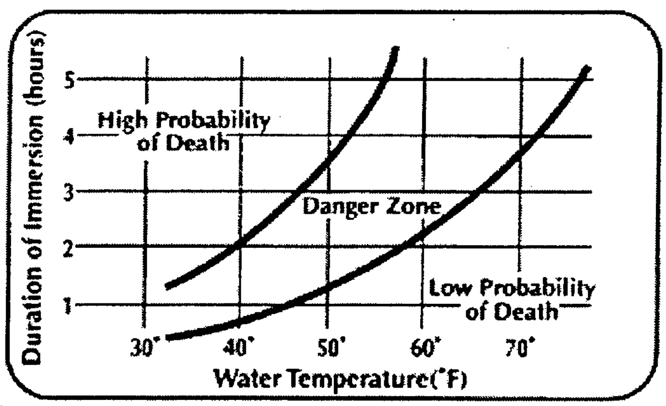

Figure 9. Water Survival Probability from Ref. 23

Higher cruise speeds enable SAR aircraft to reach potential survivors sooner, remain on station longer and ferry injured survivors ashore more expediently. A graphic comparison of maximum cruise speed is presented in Figure 10.

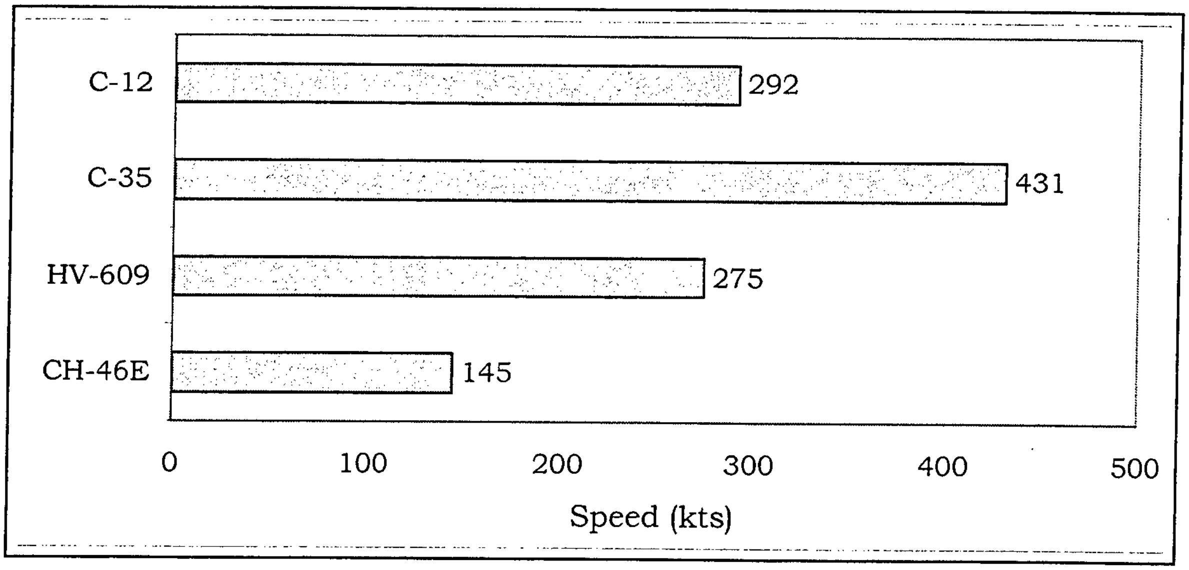

Figure 10. Maximum Cruise Speed Comparison

2. Standard Range

For peacetime utilization, all three aircraft considered for OSA operations have suitable capabilities for short-range flights as defined in the Joint Requirements Study. An aircraft with greater range could have potential benefits. Aircraft with greater range may possibly avoid refueling delays on a series of short-range flights where each leg approaches the upper limit of the short-range definition (less than 600 nm). For SAR missions, however, range is more important. Greater range is preferable because it permits both rescues at a greater distance and a broader search area. The ability to search a larger area increases the potential to save survivors' lives when time is a critical factor. A greater range and search area capability could negate the need to suspend a search in order to refuel. The HV-609's standard range is 31% greater than the CH-46E's range with internal fuel tanks.

Additionally, any gains in range that the CH-46E attains through an increased internal auxiliary fuel load are potentially offset because the extra weight lowers cruising speed. Figure 11 presents a graphical comparison of aircraft ranges.

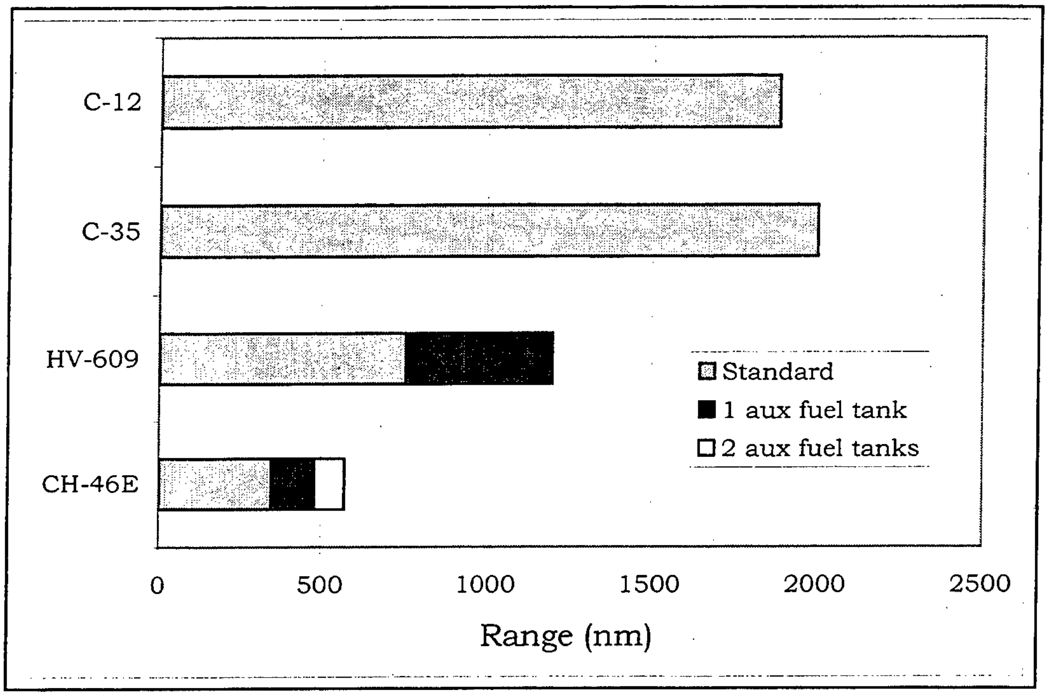

Figure 11. Range Comparison

3. Passenger and Payload Capacity

In the OSA role, passenger capacity is more important than payload capacity. While OSA requirements do encompass cargo transportation, bulk cargo would most likely be sent on larger aircraft. Each of the three aircraft examined for the OSA role possess sufficient cargo capacity to fulfill the short-range OSA requirement of 1000 lbs cargo capacity. Both the C-12 and HV-609 are capable of carrying nine passengers; the C-35, however, is only capable of carrying eight passengers. For peacetime utilization, this difference may not be significant; however, in a wartime situation, utilization rates and transportation requirements can be affected by the 12.5% lower seating capacity of the C-35.

In the SAR mission, payload capacity is more important. SAR aircraft need to have enough capacity to carry rescue personnel (crewchiefs, SAR swimmers, and medical personnel), rescued survivors and provisions for survivors that may not be immediately rescued, such as life rafts, radios, rations, and other survival gear. A graphic comparison of payload, or cargo, capacity for the SAR mission is shown in Figure 12.

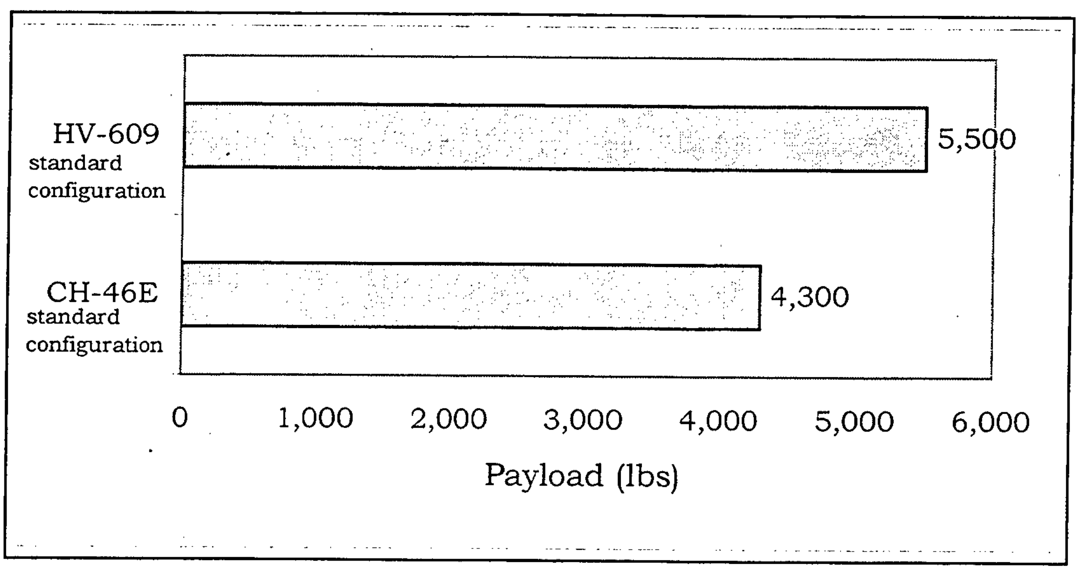

Figure 12. SAR Payload Comparison

In Figure 12, aircraft are compared based upon a standard SAR configuration. In the case of the CH-46E, this means that the internal auxiliary fuel tank is not installed. Currently, the HH-46D is always configured with the internal tank installed. However, assuming that only CH-46Es with extended range fuel cells will be converted for SAR negates this requirement. In the case of the HV-609, standard SAR configuration means that the integral wingtip tanks and auxiliary cabin fuel cell are not utilized.

4. Summary

Based on the characteristics summarized here, all four aircraft meet the minimum performance requirements necessary to be included in the alternative force structures. The C-12, C-35 and HV-609 all possess adequate airspeed, range and seating capacity to adequately fulfill the operational support airlift mission as defined by the Joint Requirement Study and USTRANSCOM. The HV-609 and the CH-46E both possess adequate speed, range and payload capacity for the Marine Corps' search and rescue mission.

IV. COST ANALYSIS

This Chapter analyzes the cost of each alternative force structure. Cost will be analyzed in terms of total life cycle costs (LCC) for each alternative force structure. Traditional life cycle cost categories are research, development, test and evaluation (RDT&E), procurement, operating and support (O&S) and disposal. Since the aircraft in the alternative force structures are commercially available and do not require extensive modification for use by the Marine Corps, RDT&E costs will not be considered. Only procurement and O&S costs will be examined in this analysis.

Costs examined include applicable procurement, conversion and annual operating and support (O&S) costs. Cost data for existing inventory aircraft were obtained from program offices, the Naval Center for Cost Analysis (NCCA) and the commercial buying services. Limited cost data for the HV-609 was obtained from Bell. All costs were converted to FY98. Net Present Value (NPV) of costs was obtained using an annual discount rate of 4.1%, as directed in OMB Circular A-94.

All DoD components maintain standardized O&S cost data for use by the Office of the Secretary of Defense. These data are referred to as Visibility and Management of Operating and Support Costs (VAMOSC) data. Ten years of VAMOSC data were obtained for the C-12 and H-46. USMC data in this data set were listed separately for the years 1988-

1995. However, due to a change made in the method of tracking USMC costs and flight hours, no separate USMC data exists for 1996-97. The USMC costs for the years after 1996 were included in the Navy command that funds their operation, specifically Atlantic Fleet and Pacific Fleet. Only the data with USMC specific cost and flying hours broken out separately were used in this thesis.

To examine costs, cost models were constructed using Microsoft Excel spreadsheets and Crystal Ball forecasting. Crystal Ball is a software "add-in" for Microsoft Excel that forecasts values based on user defined assumptions for the distribution and standard deviation of variables. For purposes of this thesis, all distributions were considered normal unless otherwise noted. Standard deviations applied to distributions were either based on historic averages or applied at 10% of the mean unless otherwise noted.

Similar cost models were utilized for each of the four alternatives. Each model calculates the total life cycle cost of each alternative force structure. Specific forecasted costs include procurement and O&S. Procurement costs involve new aircraft procurement and conversion costs for existing aircraft as applicable in each model. Total Operating and support costs are based on the sum of OSA aircraft O&S costs and SAR aircraft O&S costs. These models are presented in Appendix B.

The models were run through a simulation of 2,000 trials to enable a lifecycle cost forecast at the 90th percentile. Each model contained an aircraft fielding plan that was held constant in terms of total aircraft for OSA assets. Fielding of SAR assets was held constant in Alternatives I, II, and IIIa, but modified as necessary for Alternative IIIb. The modified SAR fielding plan reflects the reduced number of aircraft required to fulfill the SAR requirements while maintaining the same annual SAR site transition plan used in the other models. Detailed reports of the Crystal Ball forecasting trials for each Alternative are contained in Appendix C.

A. PROCUREMENT AND CONVERSION COSTS

Procurement costs for the C-12 and C-35 were obtained from an impartial third party source. Since the C-12 and C-35 are commercially available respectively as the King Air B200 and the Cessna Citation Ultra Encore, commercial market costs were used for procurement costs. This was done to ensure that there was no government or manufacturer bias in the price figures. The prices were obtained from aircraftbuyer.com for each aircraft and represent the price for a fully equipped aircraft, not the manufacturer's suggested base price. For analysis, standard deviations of these prices were estimated at 10% of the purchase price.

Procurement cost for the HV-609 was not commercially available, nor was Bell willing to divulge precise cost data, as that data is considered proprietary. Based on reliable information, conservative estimates were derived for both the OSA and SAR versions of the HV-609. Bell currently has orders for 77 aircraft at a quoted price of $8-10M (FY98) each, but will not sell any more at that price. (Ref. 24) Using $9M as a mean procurement cost and increasing it by 33% yields an estimate of $12M for an OSA variant. Likewise, an additional increase of 33%, or a 66% total increase in the mean price, provides a more conservative cost estimate of $15M for a SAR variant HV-609 for this thesis.

Conversion costs for the CH-46E were obtained from the CH-46 Class desk at the Naval Air Systems Command (NAVAIRSYSCOM). Costs provided reflect the installation of SAR specific equipment salvaged from HH-46Ds. Equipment considered in the estimate include the searchlight, the loud hailer, a commercial V/UHF radio, a crewman controller for the Doppler, and the Doppler unit. The conversion cost given indicates a minimum conversion cost that maximizes the installation of salvaged SAR specific equipment from the HH-46Ds. An alternative price indicates using all new SAR equipment. Additional costs include repainting the aircraft in SAR color schemes. A complete breakdown of expected minimum and maximum conversion costs is included in Appendix D.

To accurately portray the total conversion costs for 12 aircraft, a uniform distribution of costs was used. The lower limit of the distribution represents the absolute minimum cost based on complete equipment reuse and application of the SAR paint scheme over the top of the existing camouflage paint on the CH-46Es. The upper limit of the distribution represents the maximum cost based on purchasing all new SAR equipment and the need to strip the existing camouflage paint off the aircraft prior to applying the SAR paint scheme. A uniform distribution was chosen because it provides an equal probability that the conversion cost will fall somewhere between the minimum and maximum price. Additionally, a separate cell in the model was used for each one of the 12 CH-46Es converted, ensuring that a discrete cost was assigned to each conversion instead of one cost being assigned to all conversions for any given year.

1. Alternative I Procurement and Conversion Costs

Alternative I involves procuring new C-12s to replace existing C-12s. In this scenario, C-12s are fielded four per year for the first three years, finishing with two aircraft in the fourth procurement year, for a total of 14 aircraft. The total number of new aircraft in the force structure determines total procurement costs. In Alternative I, 14 C-12s and are required. Each new C-12 has a price of $4.11M (FY98).

Conversion costs under this alternative involve converting CH-46Es for use as SAR assets. Replacement of HH-1Ns and HH-46Ds with CH-46Es occurs at a rate of three per year for four years. Replacement of the HH-1Ns at MCAS Yuma occurs first. Each CH-46E has an estimated minimum conversion cost of $87.6K (FY98) and a maximum conversion cost of $325K (FY98). Total conversion cost for the CH-46E at the 90^{th} percentile is estimated to be $2.43M (FY98) and constitutes 4% of the total procurement cost.

Analysis of this alternative indicates that there is a 90% probability that the net present value of the total procurement and conversion cost will not exceed $60.1M. (FY98) Figure 13 graphically depicts the distribution of the NPV of procurement and conversion costs for Alternative I.

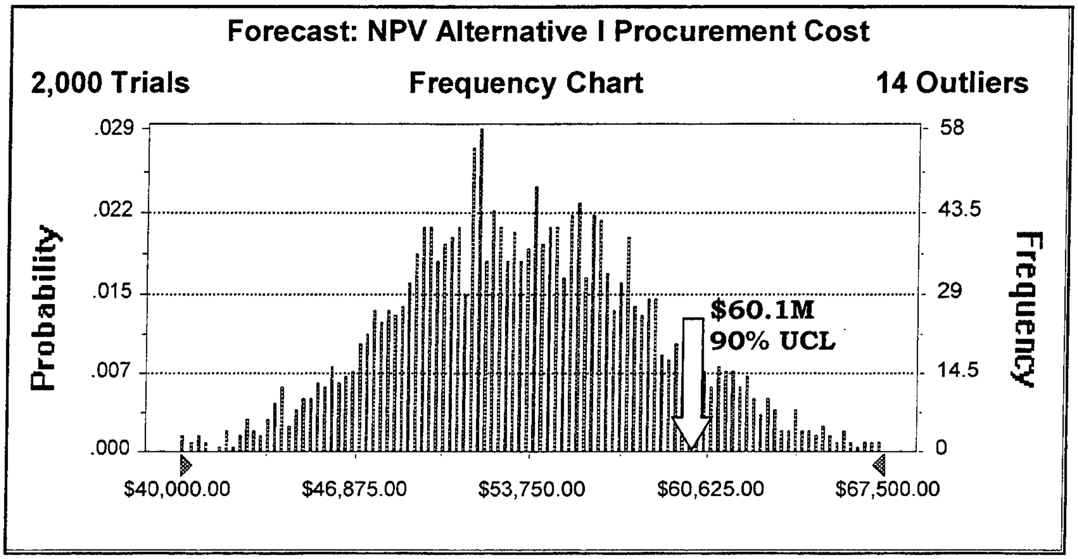

Figure 13. NPV of Estimated Alternative I Procurement and Conversion Cost

2. Alternative II Procurement and Conversion Costs

Alternative II involves procuring C-35s to replace existing C-12s. As in the Alternative I C-12 fielding scenario, C-35s are fielded four per year for the first three years, finishing with two aircraft in the final procurement year, for a total of 14 aircraft. Each C-35 has a price of $6.77M (FY98). Conversion costs for the CH-46E SAR assets under this alternative are calculated in the same fashion as in Alternative I. In this Alternative, 14 C-35s and 12 CH-46Es are required.

Analysis of this alternative indicates that there is a 90% probability that the net present value of the total procurement and conversion cost will not exceed be \$99.8M. (FY98) CH-46E conversion costs are estimated to be \$2.43M, or 2.4% of the total procurement cost. Figure 14 graphically depicts the distribution of the NPV of procurement and conversion costs for Alternative II.

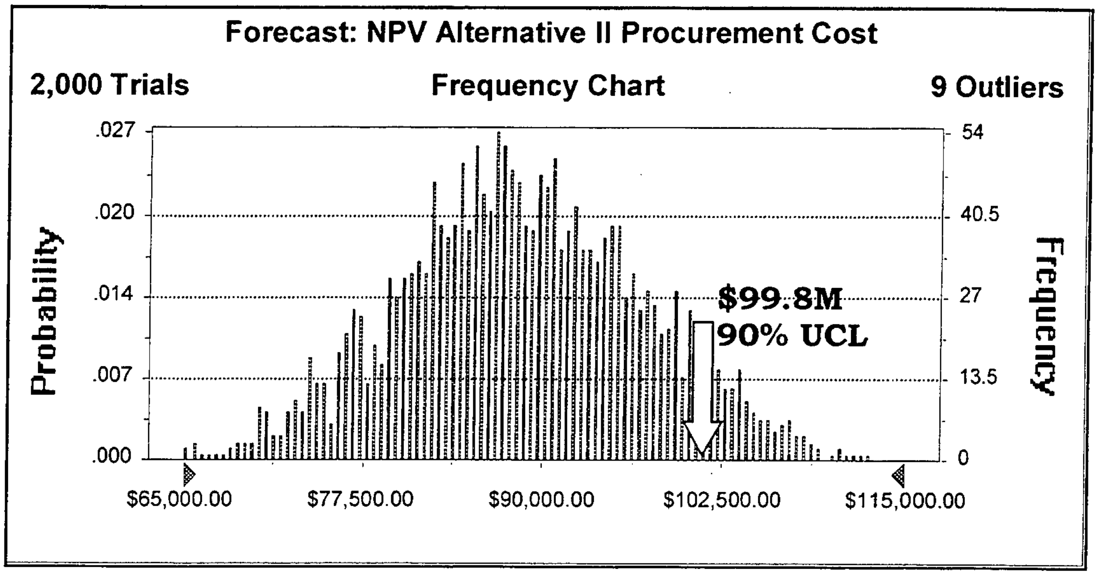

Figure 14. NPV of Estimated Alternative II Procurement and Conversion Cost

3. Alternative IIIa Procurement Costs

Alternative IIIa involves procuring OSA variant HV-609s to replace existing C-12s and SAR variant HV-609s to replace the existing HH-46Ds. Fielding of the OSA variant HV-609s followed the same timeline as the OSA fielding plans in the other alternative models, four per year for the first three years with the final two aircraft fielded in the fourth year.

Procurement and fielding of SAR variant HV-609s occur at a rate consistent with the conversion of CH-46Es in the other models. One SAR site is equipped with three HV-609s each year for the first four years of the lifecycle, beginning with MCAS Yuma. This fielding reflects a one for one replacement of HH-46Ds with HV-609s.

Total aircraft requirements for this alternative are 14 OSA variants at a cost of $12M (FY98) each and 12 SAR variants at a cost of $15M (FY98) each. A standard deviation of 25% was used instead of 10% in this analysis to reflect the uncertainty in the estimated procurement cost.

Analysis of this alternative indicates that there is a 90% probability that the net present value of the total procurement and conversion cost will not exceed $379.3M (FY98) Procurement of OSA variants accounts for 48% of the cost; SAR variants make up the other 52%. Figure 15 graphically depicts the distribution of the NPV of procurement costs for Alternative IIIa.

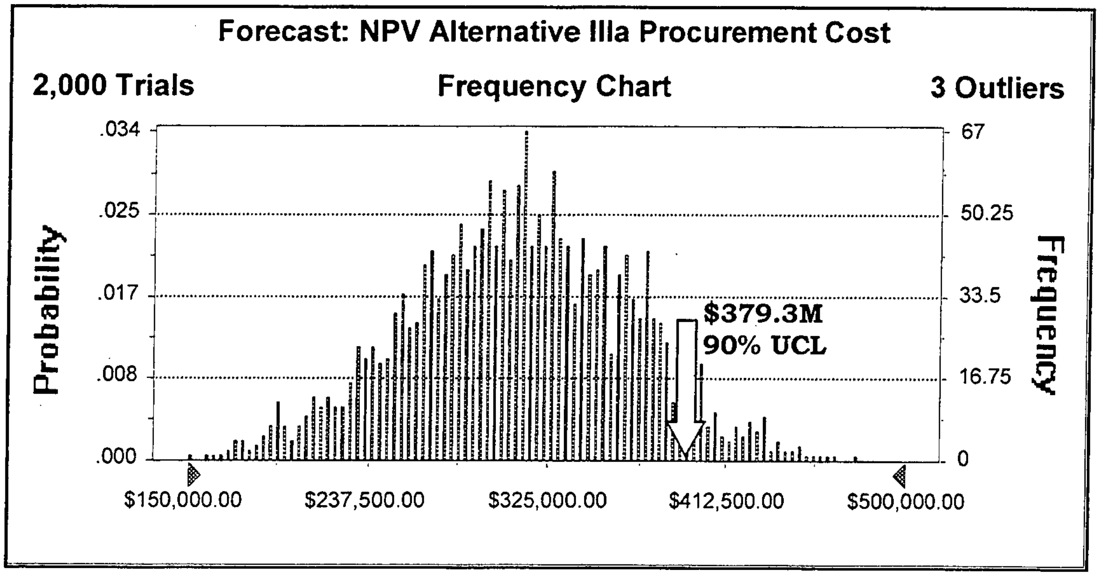

Figure 15. NPV of Estimated Alternative IIIa Procurement Cost

4. Alternative IIIb Procurement Costs

Alternative IIIb procurement cost differs from Alternative IIIa because only eight SAR variants are required to fulfill the SAR mission. Fielding is consistent with the other models in that one SAR site per year is equipped with HV-609s. This Alternative requires 14 OSA variant aircraft and eight SAR variant aircraft.

Analysis of this alternative indicates that there is a 90% probability that cost will not exceed $314.4M (FY98). Procurement of OSA variants accounts for 59% of the cost; SAR variants make up the remaining 41%. Figure 16 graphically depicts the distribution of the NPV of procurement costs for Alternative IIIb.

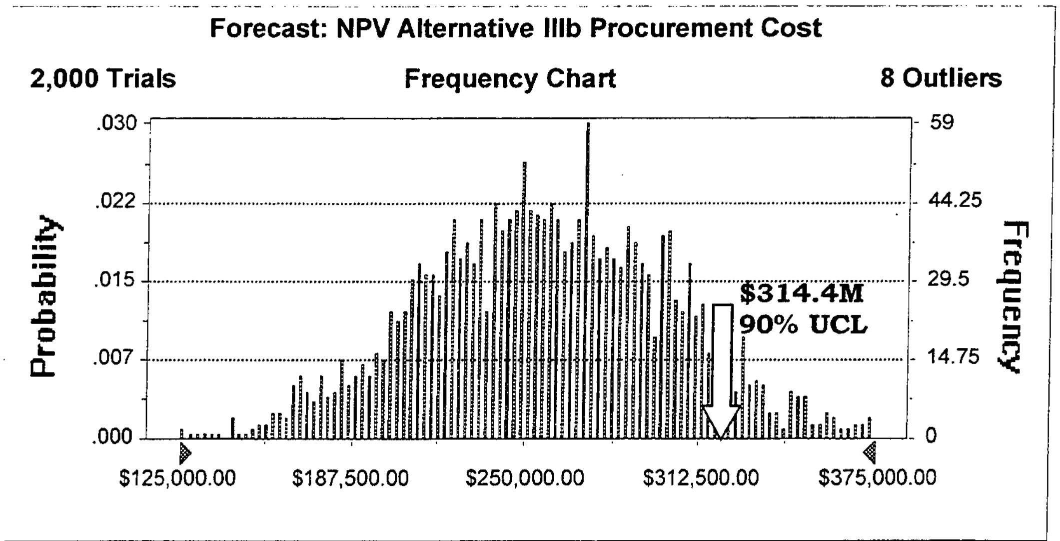

Figure 16. NPV of Estimated Alternative IIIb Procurement Cost

5. Procurement and Conversion Cost Summary

Based on net present value, Alternative I has the lowest procurement and conversion cost of all four alternatives. This will hold true as long as the procurement cost of each C-12 is less than that of the C-35. Alternative IIIa will always have the highest procurement cost because of both the procurement cost and number of SAR variant HV-609 used in the force structure. Alternatives IIIa and IIIb will always have higher procurement cost relative to Alternatives I and II because the procurement price of the HV-609 is substantially greater than the conversion cost for the CH-46E. Figure 17 shows a graphic comparison of estimated procurement and conversion costs for all four alternative force structures.

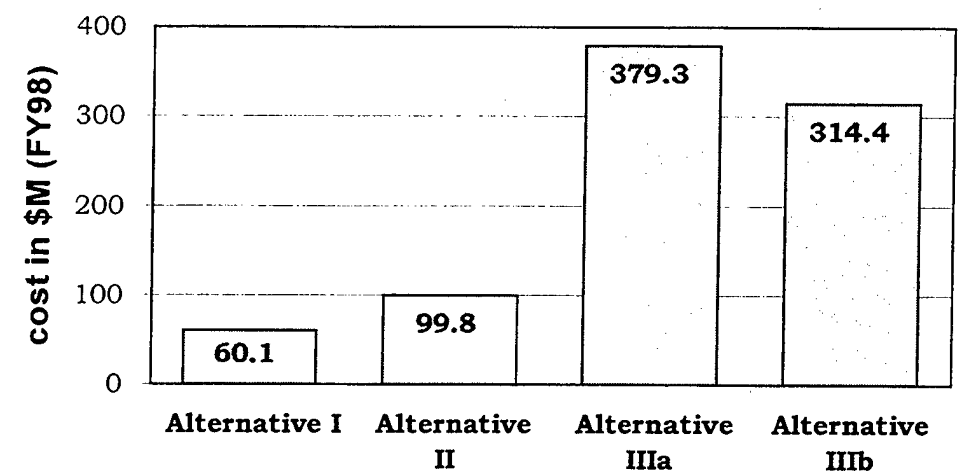

Figure 17. Comparison of Estimated Procurement and Conversion Cost

This comparison shows the significant difference in the procurement and conversion cost between the four alternatives. The procurement cost for Alternative II is $39.7M or 66% higher than that of Alternative I. Additionally, if the reliability gains proposed by Bell are realized, procurement cost of Alternative IIIa decreases $64.9M or 17%, to a cost of $314.4M, as seen in Alternative IIIb.

B. OPERATING AND SUPPORT COSTS

Operating and Support (O&S) costs for OSA assets are based upon Contract Logistic Support (CLS), or contract maintenance, costs. Since current C-12 assets are maintained under this arrangement, traditional O&S cost analysis is difficult. Traditional O&S cost analysis involves identifying cost drivers, such as spare parts, fuel, and maintenance, and their relationship to overall cost. Under CLS, the biggest cost driver is the cost of labor, a cost not easily captured in traditional VAMOSC data.

(Ref. 25) Only depot level maintenance costs, such as hot section inspections (HSI) and engine overhauls (OH), are considered separately from the contract price by the program in determining total ownership costs. (Refs. 9 and 25). Estimated CLS contract costs obtained from the C-12 and C-35 program offices were considered in this analysis. HV-609 O&S costs were estimated relative to the C-12 O&S cost estimates.

To calculate total flight time, a utilization rate was derived from the historic data. Dividing average annual flight hours by the average number of aircraft yields flight hours per aircraft per year. This was done for both the C-12 and the HH-46D. These rates were then applied to each model as an OSA utilization rate and a SAR utilization rate. The standard deviations obtained in determining the utilization rates for each mission were applied throughout all the models.

1. Alternative I O&S Costs

Operating and support costs were calculated for a 20-year period beginning with the first year of procurement. Operating and support costs for the OSA portion of this alternative are based on historical data. Comparison of VAMOSC data with program office estimates revealed significant differences in cost per flight hour. Program office estimates for the next ten years project the C-12's average cost per flight hour to be $992. This cost includes the contract maintenance cost, repairables and consumables, engine inspections and overhauls. VAMOSC data estimates an average cost of $2,320 per flight hour for all Navy and

Marine Corps C-12s. Analysis of only USMC C-12 data yields an average operating cost of $1,456. The C-12 program office provided two separate cost projections, each based on a different number of total flight hours. Considering this disparity in the cost projections, the historic (VAMOSC) USMC C-12 average cost per flight hour was used as an average O&S cost in this analysis. To reflect the operating cost of a new C-12, a 30% reduction in the historic operating cost was used. A 30% reduction in operating cost reflects expectations of better fuel efficiency and reduced maintenance requirements achieved with a new aircraft. This resulted in an hourly O&S cost of $1,019. Since the total number of aircraft remains the same for OSA assets, the historic USMC utilization rate was used.

SAR costs were estimated based on historic averages obtained from analyzing HH-46D VAMOSC data. For comparison purposes, operating costs were estimated using historic total costs vice individual cost elements. Further analysis of cost drivers for these assets would have no impact on the estimated cost since the H-46 is a legacy system in the process of being replaced. It is unlikely that any significant improvements will be made to lower operating costs. Most reductions in total operating cost are likely to come from reductions in the number of flight hours flown by these systems.

Historical averages for cost per flight hour for the HH-46D and CH-46E were used to reflect the mix of HH-46Ds and CH-46Es in the force structure until all HH-46Ds are replaced. Flight hours were allocated based on a ratio of CH-46Es to HH-46Ds. The distribution of the forecasted NPV of O&S costs for Alternative I are depicted in Figure 18. Analysis of this alternative indicates that there is a 90% probability that the NPV of the total O&S cost will not exceed $511.7M (FY98).

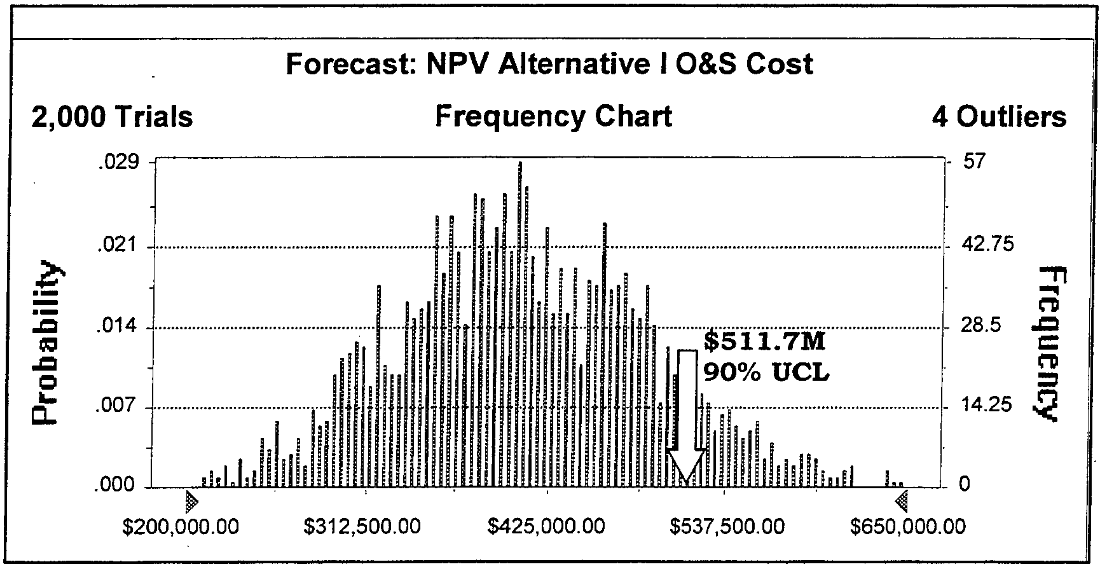

Figure 18. NPV of Estimated Alternative I Operating and Support Cost

2. Alternative II O&S Costs

Operating and support costs were calculated for a 20-year period. Operating and support costs for the OSA portions of this alternative are based on projected averages of C-35 Logistic Contract Support prices obtained from the program office and historic averages of flight hours from VAMOSC data. Since the Army Cost and Economic Analysis Center was unable to provide historic data for their C-35s, program funding from the NAVAIRSYSCOM C-35 program office was used. The C-35 program office provided current estimates for program funding for the two existing C-35s in the USMC Reserve. Basic annual contract logistic support cost for the two USMC Reserve sites was averaged to determine O&S costs. This cost excluded hot section inspections (HSI) and engine overhauls (O/H). Costs for HSIs were calculated by dividing the estimated cost of the inspection by the mean time between inspections. This provided a cost per hour for the HSI that was added to the program office's O&S cost estimate. Engine overhaul costs were derived similarly, and likewise added to the O&S cost. Incorporating HSI and O/H costs provides a more accurate portrayal of total costs. The hourly O&S cost used for the C-35 was $658. Additionally, since CLS for a new model aircraft is being initiated, a site activation fee was calculated in for each site during procurement. While fielding the C-35, O&S costs for OSA are allocated to both the C-12 and C-35 based on ratio of the total numbers of each aircraft in the inventory.

Since this alternative has the same SAR force structure as Alternative I, the SAR O&S costs were calculated as in Alternative I. Distribution of the forecasted NPV of O&S costs for Alternative II with a 90% UCL are depicted in Figure 19. Analysis of this alternative indicates that there is a 90% probability that the NPV of the total O&S cost will not exceed $456.6M (FY98).

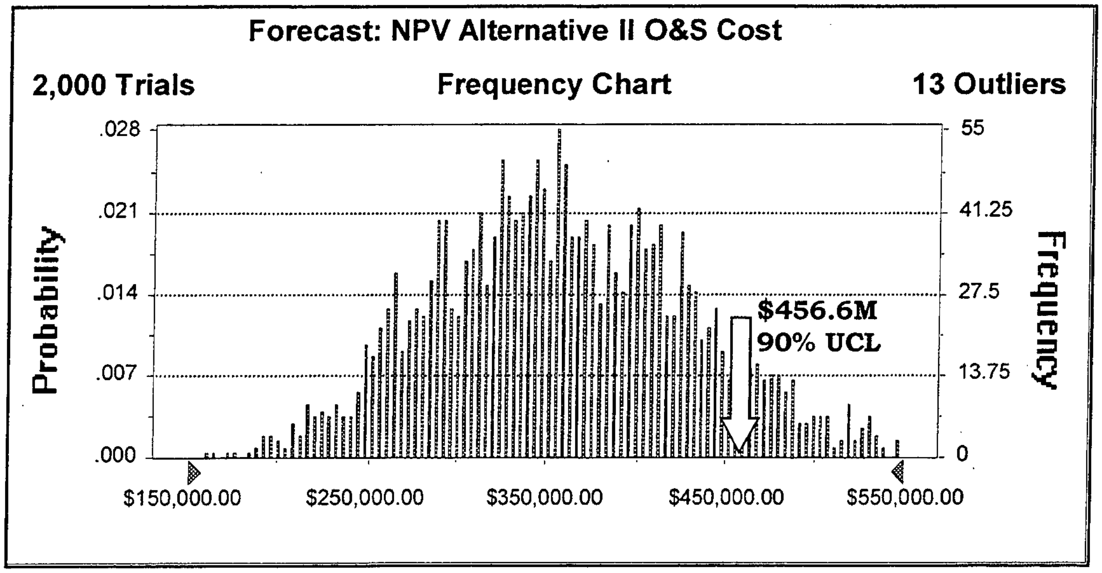

Figure 19. NPV of Estimated Alternative II Operating and Support Cost

3. Alternative IIIa O&S Costs

Bell provided a rough direct operating cost estimate of $850 per flight hour. This figure is based on commercial use and consists of consumables, repairables, fuel and maintenance. Bell claims that this low direct operating cost will be attainable through the reliability features and component lifetimes designed and built into the aircraft. The complexity of the tiltrotor mechanics, however, cannot be ignored. Under government funded CLS, it would not be unreasonable to assume that O&S cost for the HV-609 would be at least equal to or slightly higher than that of a new C-12, particularly since both aircraft use different models of the same engine, the Pratt & Whitney PT6A. Therefore, a cost that reflects a ten percent increase over the estimated new C-12 O&S cost was used. The hourly O&S cost that was used is 31.8% higher than

Bell's estimate, or $1,121. While fielding the HV-609, O&S costs for OSA are allocated to both the C-12 and HV-609 based on ratio of the total numbers of each aircraft in the inventory. Additionally, appropriate site activation costs for the initiation of CLS for a new airframe were factored into this model, as in Alternative II.

As in Alternatives I and II, the utilization rate of the HH-46D was used to forecast annual SAR O&S costs. The average cost per flight hour for the HH-46D, the projected costs per flight hour for the HV-609 and the historic utilization rate were used to reflect the mix of HH-46Ds and HV-609s in the force structure until all HH-46Ds are replaced. Analysis of this alternative indicates that there is a 90% probability that the NPV of the total O&S cost will not exceed $315.9M (FY98) Figure 20 depicts the forecasted distribution of the net present value of Alternative IIIa O&S cost.

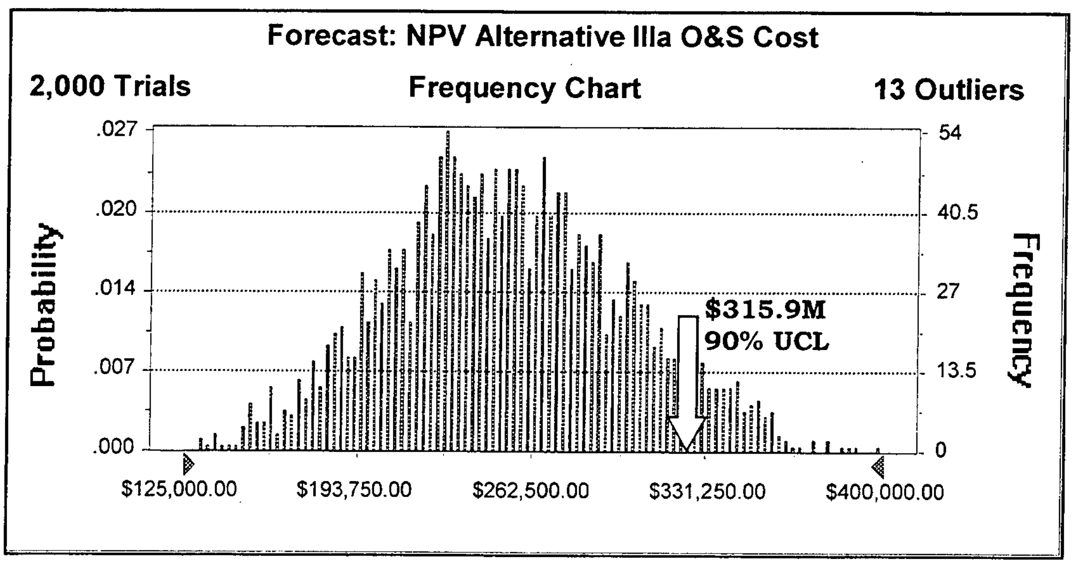

Figure 20. NPV of Estimated Alternative IIIa Operating and Support Cost

4. Alternative IIIb O&S Costs

Alternative IIIb O&S cost is calculated based on historical utilization rates for OSA aircraft and total SAR flight hours. Even though this alternative uses fewer aircraft to accomplish the SAR mission, the same annual flight hours are applied. To estimate the SAR utilization rate for this alternative, the historic annual SAR flight hours were divided by the number of proposed SAR variant HV-609s. This resulted in a utilization rate 50% higher than the historic utilization rate.

The average cost per flight hour for the HH-46D, the projected costs per flight hour for the HV-609, the historic SAR utilization rate and the proposed revised HV-609 utilization rate were used to reflect the mix of HH-46Ds and HV-609s in the force structure until all HH-46Ds are replaced. Analysis of this alternative indicates that there is a 90% probability that the NPV of the total O&S cost will not exceed $317.1M (FY98) Figure 21 depicts the forecasted distribution of the net present value of Alternative IIIb O&S cost.

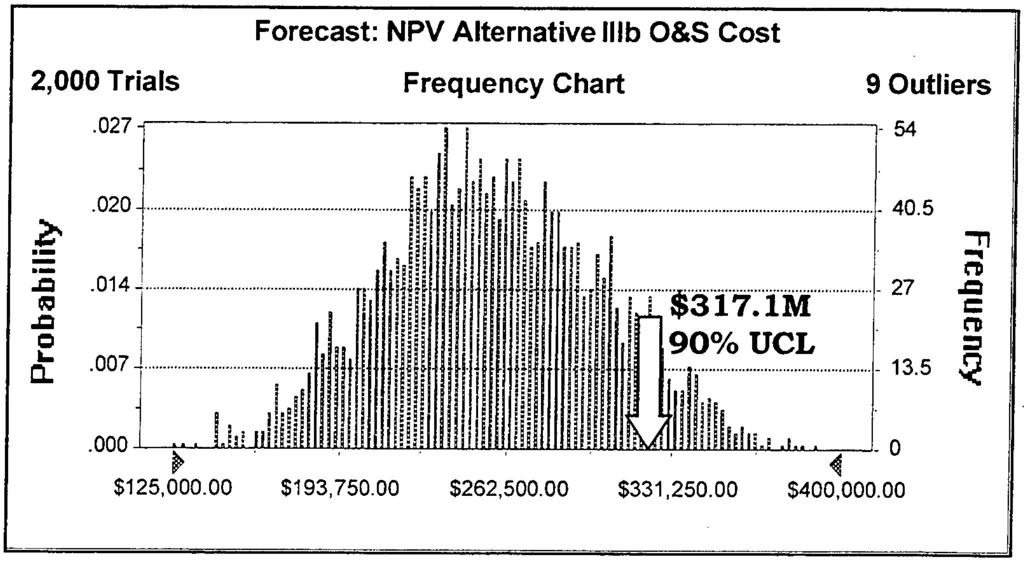

Figure 21. NPV of Estimated Alternative IIIb O&S Cost

5. O&S Costs Summary

With the values used in the analysis, Alternatives IIIa and IIIb have the lowest estimated O&S cost of the alternatives. The $1.2M difference seen between Alternative IIIa and IIIb is a result of the variability forecasted in each model and amounts to only a 0.04% difference. Alternatives IIIa and IIIb provide lower O&S cost because of the high O&S cost for the CH-46E. At an estimated $5,490 per hour, the CH-46E operating cost is 390% higher than that of the estimated HV-609 hourly operating cost. Because of this, Alternatives IIIa and IIIb will always have lower overall O&S costs than Alternatives I and II. Alternative II O&S costs are $55M or 10% less than Alternative I cost due to the lower hourly operating cost of the C-35. The estimated hourly cost of the C-35 is 35% or $361 less than the hourly cost of the C-12. Figure 22 shows a graphic comparison of O&S costs for all four alternative force structures.

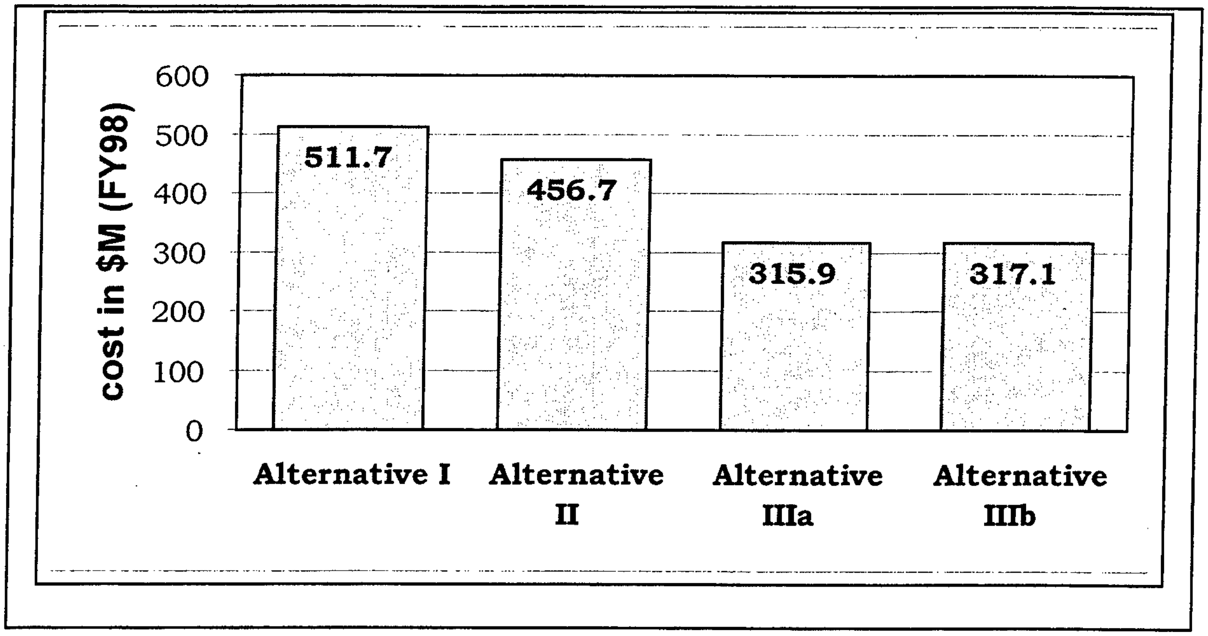

Figure 22. Comparison of Estimated Operating and Support Cost

C. SUMMARY OF COSTS

Adding estimated procurement and conversion cost, and the estimated operating and support cost of each alternative force structure yields estimated total life cycle costs. Figure 22 graphically depicts the estimated NPV of total lifecycle costs for each of the four alternatives at the 50th percentile.

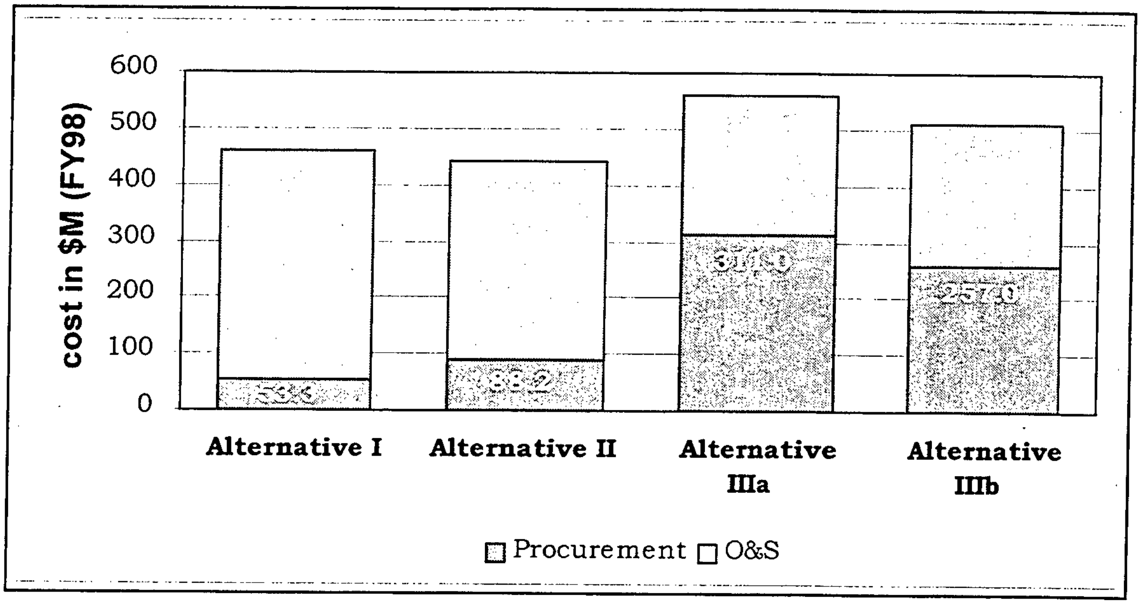

Figure 23. Comparison of Estimated 50th Percentile Total Cost

Figure 23 shows that at the median cost represented by the 50th percentile, Alternative II has the lowest overall LCC, followed by Alternative I. Despite having higher procurement costs, Alternatives IIIa and IIIb have lower O&S costs relative to total LCC. Alternative I O&S cost constitutes 88% of total LCC. Alternative II O&S cost constitutes 80% of total LCC. Alternative IIIa O&S cost constitutes 45% of total LCC. Alternative IIIb O&S cost constitutes 50% of total LCC. At this percentile there is a difference of $117.9M or 26% in total cost between the least expensive and most expensive Alternative.

Figure 24 shows the NPV of total lifecycle costs at the 90th percentile. Analysis of all four alternatives indicates that there is a 90% chance that the total procurement cost would not exceed $652.1M (FY98) regardless of the alternative selected. At the 90th percentile, the difference in cost between the least expensive and most expensive alternative is reduced from $117.9M to $106.8M.

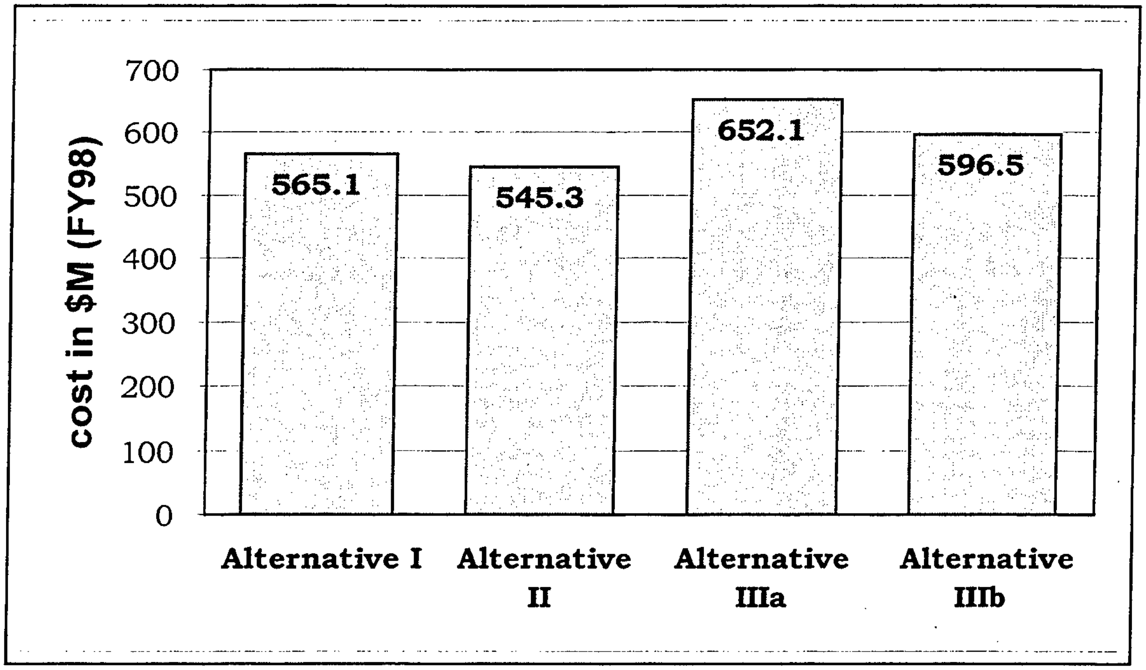

Figure 24. Comparison of Estimated 90th Percentile Total Costs

This shows that at a higher degree of certainty, the overall lifecycle cost still favors Alternative II. However, when forecasting cost variability, the difference between the least expensive and most expensive alternative is reduced from 26% to 19.5% of the estimated total cost.

4. MANPOWER COSTS

The commonality of OSA and SAR assets in Alternatives IIIa and IIIb provides the potential for reducing manpower costs. If contract maintenance is available for both variants of the HV-609, direct maintenance manpower requirements may be reduced in two of the proposed alternative force structures. Direct maintenance refers to those

Marines with appropriate Military Occupation Specialties (MOSs) who are directly involved in maintaining the SAR aircraft. The MOSs considered direct maintenance for the purposes of this thesis include line mechanics (MOS 6112 and 6114), airframes mechanics (MOS 6152 and 6154) and avionics mechanics (MOS 6322 and 6324). Table 2 summarizes the February 1999 Troop List requirements for direct maintenance Marines supporting SAR units at MCAS Cherry Point, MCAS Beaufort, MCAS Iwakuni and MCAS Yuma.

	MOS	E7	E6	E5	E4	E3	total
Iwakuni	6112 H-46 mechanic	1	0	3	2	0	6
	6152 H-46 airframes	1	2	2	0	4	9
	6322 H-46 avionics	1	1	2	3	0	7
	site total	3	3	7	5	4	22
Beaufort	6112 H-46 mechanic	1	2	1	0	3	7
	6152 H-46 airframes	2	2	3	1	3	11
	6322 H-46 avionics	1	1	2	2	1	7
	site total	4	5	6	3	7	25
Cherry Point	6112 H-46 mechanic	1	1	2	0	3	7
	6152 H-46 airframes	1	2	2	1	3	9
	6322 H-46 avionics	2	1	1	1	2	7
	site total	4	4	5	2	8	23
Yuma	6114 H-1 mechanic	1	2	0	3	2	8
	6154 H-1 airframes	0	3	1	0	2	6
	6324 H-1 avionics	1	1	1	1	1	5
	site total	2	6	2	4	5	19
TOTAL		13	18	20	14	24	89

Table 2 Current SAR Direct Maintenance Manpower Requirements

Indirect manpower costs, such as administrative clerks and operations specialists, were omitted from the comparisons because these numbers would be the same in each alternative force structure. Pilot's wages were also excluded from the analysis, as they are not specifically attributable to these billets. Pilots in C-12 billets are normally assigned to other jobs on the base at which the aircraft are located. Flying duties are secondary to the station billets the pilots hold. SAR pilot billets would not change in number under any of the proposed alternatives. Pilots are not specifically assessed into USMC aviation for SAR or C-12 duty and these costs would be incurred regardless of these billets. Enlisted manning levels at SAR units are impacted by the various alternative force structures and each model reflects net changes in the costs associated with direct maintenance Marines involved.

1. Alternative I and II Manpower Costs

The total number of pilots and crewchiefs required for C-12 and C-35 billets would remain unchanged in these alternatives. Manning requirements for current HH-46D SAR units would also remain unchanged, but the H-1 maintenance specific requirements at MCAS Yuma would be changed to H-46 maintenance specific requirements. By analyzing the Troop List requirements for the H-46 SAR sites and Yuma, a difference in the manning requirement was identified.

Utilizing MCAS Beaufort as a model, establishing H-46 maintenance at MCAS Yuma involves the addition of six Marines in various paygrades. MCAS Beaufort was chosen as it represents a typical SAR unit. The total direct maintenance manpower requirements for the search and rescue mission in Alternatives I and II are provided in Table 3.

	E7	E6	E5	E4	E3	total
Iwakuni	3	3	7	5	4	**22**
Beaufort	4	5	6	3	7	**25**
Cherry Point	4	4	5	2	8	**23**
Yuma	4	5	6	3	7	**25**
TOTAL	15	17	24	13	26	**95**

Table 3. Alternative I and II Direct Maintenance Manpower Requirements

This manpower requirement can be converted into a cost by using a composite wage scale obtained from the O&S Costing Division at NAVAIRSYSCOM. Table 4 reflects the annual manpower cost associated with Alternatives I and II. This cost already is included in the O&S cost discussed previously and is only identified here as a comparative cost measure.

	E7	E6	E5	E4	E3
Total Marines	15	17	24	13	26
Composite wage	$51,600	$44,594	$36,385	$30,184	$25,786
Total wages	**$774,000**	**$758,098**	**$873,240**	**$392,392**	**$670,436**

Table 4. Alternative I and II Annual Direct Maintenance Manpower Cost

The total annual manpower cost associated with direct maintenance Marines for Alternatives I and II is $3.47M (FY98). Net present value of this cost over the twenty-year lifecycle is $39M. For Alternative I, this represents 7.6% of total O&S cost. For Alternative II, this represents 8.5% of total O&S cost.

2. Alternative IIIa and IIIb Manpower Costs

Under these Alternatives, a cost savings due to a reduction in the total number of Marines required to maintain the SAR assets is realized. With contract maintenance for both HV-609 variants, helicopter specific maintenance is no longer required. As seen in Table 2, a total of 89

Marines from MCAS Cherry Point, MCAS Beaufort, MCAS Iwakuni and MCAS Yuma fall into the direct maintenance category. These Marines would not be needed at these sites if contract maintenance were used in these alternative force structures, resulting in a reduction of 89 billets once all sites are converted from the HH-46D to the HV-609. This amounts to annual savings of $3.24M (FY98). While fielding the HV-609, there would be a reduced manpower cost associated with the maintenance of the HH-46s still in use. These costs are presented in Table 5.

	YR 0	YR 1	YR 2	YR 3	YR 19
Annual Manpower Cost	$2,549,000	$1,716,000	$919,000	0	0

Table 5. Alternatives IIIa and IIIb Annual Direct Maintenance Manpower Costs

Net present value of this annual cost over the twenty-year lifecycle cost is only $4.5M (FY98) for both Alternative IIIa and IIIb. This is insignificant, as it is only 1.4% of the total O&S cost.

3. Manpower Costs Summary

The manpower cost comparison illustrates potential cost savings as a result of using contract maintenance for SAR assets. Alternatives I and II O&S costs include the manpower costs discussed by virtue of the CH-46E VAMOSC data used. The CH-46E VAMOSC data incorporates direct maintenance Marines. C-12 VAMOSC data does not incorporate direct maintenance Marines because Marines are not used to maintain these assets. The estimated O&S cost of the HV-609 likewise does not reflect direct maintenance Marines because of the assumed contract logistic support.

This comparison highlights the potential manpower changes available through contract logistic support. If contract maintenance is used in Alternative IIIa and IIIb, the direct maintenance billets can be eliminated, resulting in the reassignment of 89 Marines to fleet units or a reduction in total force structure requirements.

E. SENSITIVITY ANALYSIS

By conducting sensitivity analysis of certain variables, the significance of those variables in formulating total lifecycle cost can be determined. Sensitivity analysis was performed on the following variables: new C-12 O&S cost, HV-609 O&S cost and the percentage used for standard deviation in all costs.

1. O&S Cost Sensitivity

The O&S cost for the new C-12 was originally estimated by reducing the historic C-12 O&S cost by 30%. A second analysis was conducted with an O&S cost for the new C-12s equal to the historic O&S cost. This was done to reflect the case in which the new C-12s show no improvement over the old C-12s in terms of operating cost. This analysis indicated that there is a 90% probability that the NPV of Alternative I would not exceed $642.6M (FY98), an increase of $77.5M or 13.7% over the initial analysis. This increase makes Alternative I the second most expensive of the four alternatives, behind Alternative IIIa. Alternative II remains the lowest cost alternative, followed by Alternative IIIb.

The operating cost of the HV-609 was estimated relative to the operating cost of a new C-12. This provided a cost of $1,121 per hour. However, Bell claims that the O&S cost will be approximately $850 per hour. A third analysis was conducted using Bell's estimated operating cost for the HV-609. This analysis indicated that there is a 90% probability that the NPV of Alternative IIIa would not exceed $601.2M (FY98), a decrease of $51M or 7.8% over the initial analysis. Likewise given the previous assumptions, the analysis also indicates that the NPV of Alternative IIIb would not exceed $539.5M, a decrease of $57M or 9.5% over the initial analysis. At this level of certainty, Alternative IIIb costs 2%, or $12M, less than Alternative II.

2. O&S Cost Breakeven Analysis

Breakeven analysis was conducted to determine at what O&S cost Alternatives I, IIIa and IIIb become the least expensive alternative. For the breakeven analysis, all procurement and conversion costs were held constant, as were the CH-46E O&S costs. Only the O&S cost for the new C-12 and HV-609 were considered in the breakeven analysis. The analysis indicates that the average net present value of Alternative I is the lowest of all the alternatives when the operating cost of the new C-12 is $915 per hour. Likewise, Alternative IIIb becomes the least expensive alternative when the operating cost of the HV-609 is $769 per hour.

Alternative IIIa does not become the least expensive alternative until operating cost of the HV-609 is $497 per hour.

3. Standard Deviation Sensitivity

Throughout this thesis, a standard deviation of 10% was used in the absence of historical data. This allows for a very narrow distribution of costs. To portray a greater degree of uncertainty in the acquisition process, a fourth analysis was conducted using a 25% standard deviation for all variables except those with historic standard deviations, namely utilization rates and CH-46E O&S costs. This analysis shows that while overall cost increases at the 90th percentile due to increased variability, the relative cost of each alternative remains the same. Alternative II is still the least expensive alternative, followed by Alternative I, Alternative IIIb, and finally Alternative IIIa. The analysis indicates that there is a 90% probability that cost would not exceed $673M (FY98) regardless of the alternative selected.

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V. OPERATIONAL EFFECTIVENESS ANALYSIS

This Chapter evaluates the operational effectiveness of the aircraft used in each alternative force structure based upon measures of effectiveness for the OSA and SAR missions.

A. MEASURES OF EFFECTIVENESS

To assess overall operational effectiveness of each proposed alternative force structure, suitable measures of effectiveness (MOEs) are required for the two missions that each alternative force structure must perform. For the OSA mission, total travel time is the overriding concern when examining the performance capabilities of the aircraft being considered. Three separate measures of effectiveness encompass the entire OSA mission profile: air travel time, total travel time, and landing site requirements. For the SAR mission, the ability to locate and rescue survivors in a timely manner is the principle aircraft performance factor. The MOEs selected for SAR reflect the capability to continue a search for an extended time in order to successfully rescue survivors: range versus time on station and payload versus range.

1. Air Travel Time in OSA Missions

A comparison of aircraft range versus time required to travel a given distance will highlight the effectiveness and gains available through higher aircraft cruising speeds. For OSA asset comparison, mission profiles of 300 and 600 nm were used. Airspeeds used were derived from the optimum altitude for the distance flown, based on standard day conditions. Comparisons made here illustrate the actual flight time required to fly the designated distance, and include the time to climb to cruising altitude and approach time but exclude ground taxi time and any potential ground transportation delays. Computations are based on best cruising speed and altitude obtained from aircraft manufacturers. This comparison is shown in Figure 25.

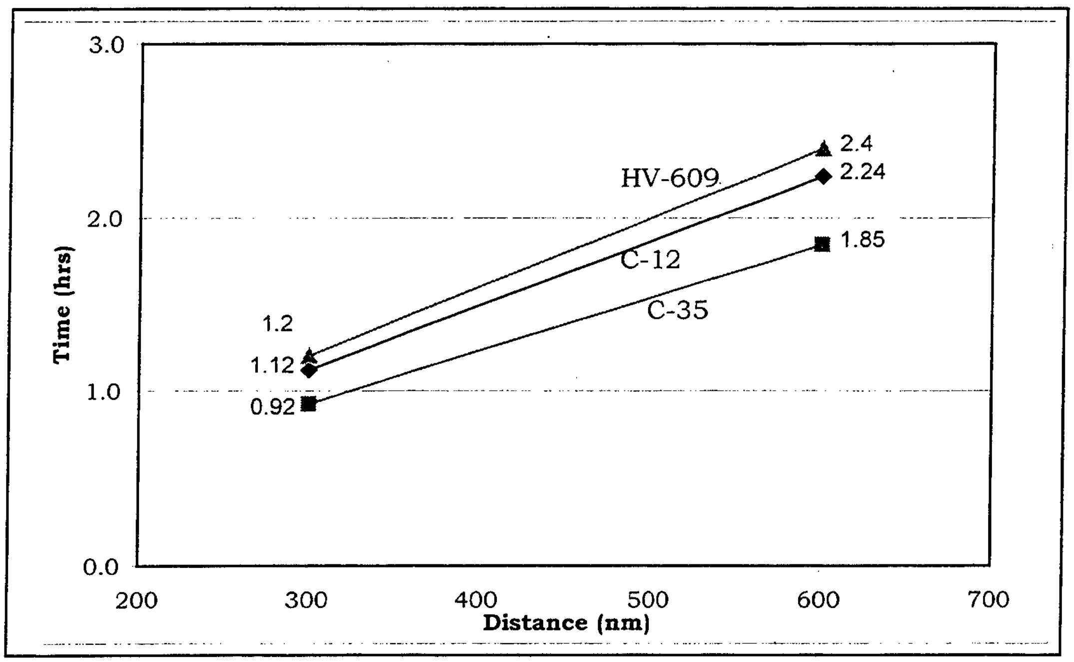

Figure 25. OSA Air Travel Time

Based on this comparison, the C-35 used in Alternative II has the best air travel time across all distances considered. On travel legs of 300 nm, the C-35 is 12 minutes faster than the C-12 and 17 minutes faster than the HV-609. When the trip distance is increased to 600 nm, the C-35 is 23 minutes faster than the C-12 and 33 minutes faster than the

HV-609. As can be seen in Figure 1, the C-12 used in Alternative I is also faster than the HV-609 used in Alternatives IIIa and IIIb across all distances. If this were the only MOE, Alternative II would offer the best performances.

2. Total Travel Time in OSA Missions

Although not directly measurable, versatility is a parameter to consider in comparing aircraft. Traditional fixed wing aircraft require some sort of prepared runway. In peacetime, these assets operate from airports and airfields, both civilian and military. In larger metropolitan areas, these airfields are not always located adjacent to military staff facilities. For example, a General Officer from the Pentagon must travel via automobile or helicopter to any one of a number of outlying airfields to get on a C-12: Andrews Air Force Base, Davison Army Airfield, or Marine Corps Air Facility Quantico. Traffic delays in metropolitan areas may negate any gains in a higher cruising airspeed. A tiltrotor does not require a prepared runway or landing site. Like a helicopter, a tiltrotor can land just about anywhere to pick up passengers, negating the need for additional transportation, either air or ground. Therefore, applying a ground transportation delay to the C-12 and C-35 in the scenario outlined above, more accurately portrays the total travel time.

In the Washington D.C. metropolitan area, the average ground transportation traffic delay is estimated to be 30 minutes. Additionally, sources in the commercial sector utilize 30 minutes as a low estimate and one hour as a high estimate for traffic delays applied to each end of travel in assessing executive transportation requirements. (Ref. 26) Using the same distances and airspeeds contained in Figure 25 and applying a normal distribution to a 30-minute ground delay at each end of the air travel for Alternatives I and II, a forecast for total travel time can be obtained. Since there are no guarantees that ground travel delays would never be encountered with the HV-609, a delay of 15 minutes was factored into the air travel time for Alternatives IIIa and IIIb. Figure 26 shows the forecasted average total travel times for each alternative for flights of 300 and 600nm.

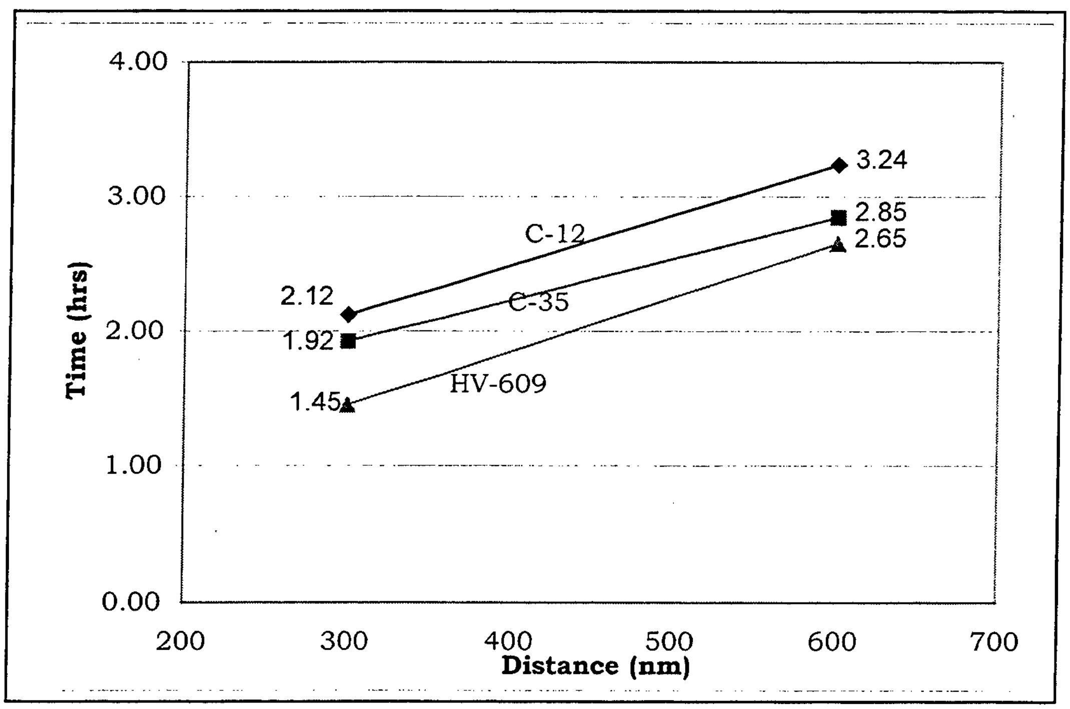

Figure 26. OSA Total Travel Time

As seen in Figure 26, when potential ground delays are factored in, the HV-609 in Alternative IIIa and IIIb offers the lowest travel time across the distances considered. At distances of 300 nm, the HV-609 is 28 minutes faster than the C-35 and 40 minutes faster than the C-12. When the distance is increased to 600 nm, the HV-609 is 12 minutes faster than the C-35 and 35 minutes faster than the C-12. As can be seen in Figure 25, the slope of the trend line for the C-35 indicates that as the mission profile is extended, traffic delays are compensated by the increased airspeed available in Alternative II. The difference in travel time between the HV-609 and C-35 decreases from 24% to only 7% when the distance increases from 300 nm to 600 nm. However, due to the mission range requirements of only 600 nm, Alternatives IIIa and IIIb provide the best performance relative to total travel time and potential ground delays.

3. Landing Site Requirements

By examining the entire mission profile for an OSA mission, a more distinct measure of effectiveness and versatility is obtained. Besides contributing to potential ground delays, fixed wing aircraft landing site constraints can also limit access to remote operating areas. Aircraft in Alternatives I and II are limited to prepared runways with a minimum length between 3000 and 3300 feet long. The HV-609 used in Alternative III does not require a prepared runway, only a site that provides adequate prop-rotor clearance and a suitable ground surface. In both peacetime and wartime, General Officers and other VIPs are often transported between airfields and operational field units via helicopters at the conclusion of the fixed wing portion of travel in OSA missions. The helicopter assets utilized for these missions are usually fleet assets. The ability of a tiltrotor to take off and land virtually anywhere allows FMF helicopter assets to otherwise support FMF units, and not the operational support airlift mission.

4. Range versus Time on Station for SAR Missions

The overall effectiveness of each alternative force structure must encompass a measure of how well the proposed force structure can accomplish the search and rescue mission. Comparing SAR aircraft range versus time on station, suggests a measure of search and rescue capability and operational effectiveness for each alternative force structure. For SAR asset comparison, mission profiles of 50 and 125 nm were used. Since time is considered a critical element in search and rescue operations, the aircraft's specified maximum airspeed was used in comparing range versus time. Based on minimum transit times to and from specific distances, a loiter time, or time on station (TOS) was derived and used as a measure for comparison. The data contained in Table 6 represents data for both the CH-46E and HV-609 in standard fuel configuration and extended range fuel configurations.

	Fuel load	Distance one way (nm)	Airspeed (kts)	Total Transit Time (hrs+min)	Time on Station (hrs+min)
CH-46E	standard	50	145	0+41	2+19
	1 aux tank	50	145	0+41	3+19
	standard	125	145	1+44	1+16
	1 aux tank	125	145	1+44	2+16
HV-609	standard	50	275	0+22	2+38
	aux tank	50	275	0+22	3+38
	standard	125	275	0+55	2+05
	aux tank	125	275	0+55	3+05

Table 6. CH-46E and HV-609 Range and Time on Station

By applying a minimum required time on station of 30 minutes to each aircraft, maximum ranges can be derived for both aircraft in different fuel load configurations, delineating a SAR performance envelope. Airspeeds utilized in this derivation represent maximum performance; actual performance on any given day would be different. Figure 27 shows the standard and extended range versus time on station comparisons for the CH-46E and the HV-609.

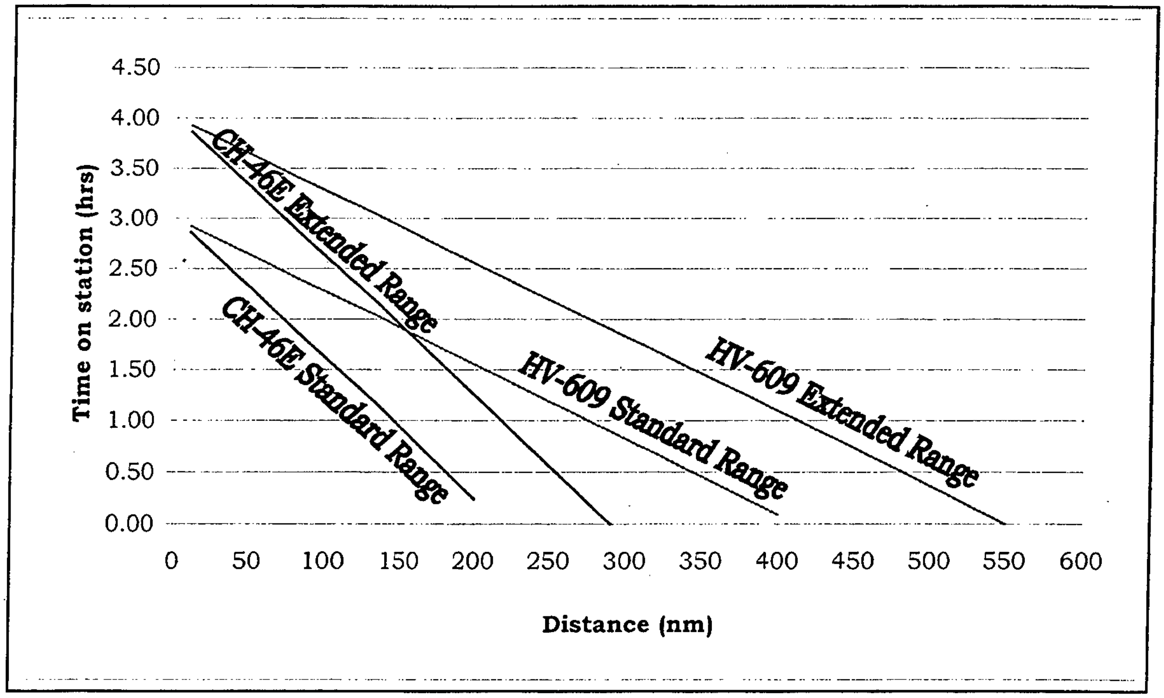

Figure 27. SAR Range versus Time on Station

Figure 27 shows the advantages that Alternative IIIa and IIIb offer in time on station over Alternatives I and II. On shorter range flights, time on station is comparable. However, the difference in time on station becomes more pronounced as range increases. At 100 nm, the HV-609's time on station is 40% greater than the CH-46E. At 150 nm, the time on station for the HV-609 without auxiliary fuel is the same as the CH-46Es time on station with auxiliary fuel. This reflects the rate at which each aircraft consumes fuel. At greater ranges, the HV-609 will experience lower fuel consumption because it is flying like a conventional airplane. Moreover, as consumption goes down, more fuel is available to remain on station. The HV-609 need only convert to helicopter operations once the survivors are actually located and are ready for pick up.

5. Payload versus Range for SAR Missions

A comparison of payload versus range for SAR missions also determines search capability and effectiveness. Both the CH-46E and the HV-609 utilize auxiliary fuel cells that increase range, but decrease payload capacity and limit the rescue personnel and provisions available for a rescue mission. For the CH-46E, an increase in range of 210 nautical miles decreases available payload weight capacity by nearly 80%, and decreases seating capacity from 18 to 6. Additional payload and range tradeoffs as a function of fuel load for the CH-46E and the HV-609 are provided in Table 7.

	Payload (lbs)	Useful Fuel (lbs)	Fuel burn (lbs/hr)	Endurance (hrs + min)	Airspeed (kts)	Available seating	Range (nm)
CH-46E	4300	4000 standard fuel	1350	3+00	120	18	360
	2600	5600 1 aux tank	1400	4+00	120	12	480
	900	7100 2 aux tanks	1500	4+45	120	6	570
HV-	5500	2480 std fuel load	900	2+45	250	9	750
	3875	4105 aux fuel load	1000	4+00	250	9	1200

Table 7. CH-46E and HV-609 Payload Data

The HV-609 experiences a less dramatic decrease in payload weight capacity in the tradeoff for extended range. With auxiliary fuel onboard, the HV-609s payload capacity is decreased by 30%. Seating capacity is unaffected by the addition of extra fuel; the cabin fuel cell is an integral fuel cell designed into the aircraft's fuselage.

Actual aircraft performance will vary with prevailing weather conditions. Generally, however, as aircraft gross weight increases, fuel consumption also increases. The figures used in Table 7 represent averages for the CH-46E and estimated averages for the HV-609 over the entire spectrum of flight operations. Payload refers to the payload capacity available with the corresponding amounts of useful fuel. Airspeed indicates the average cruising speed that most closely approximates the maximum range airspeed. Figure 28 shows the gains in range versus the payload lost to the additional fuel for the CH-46E and HV-609.

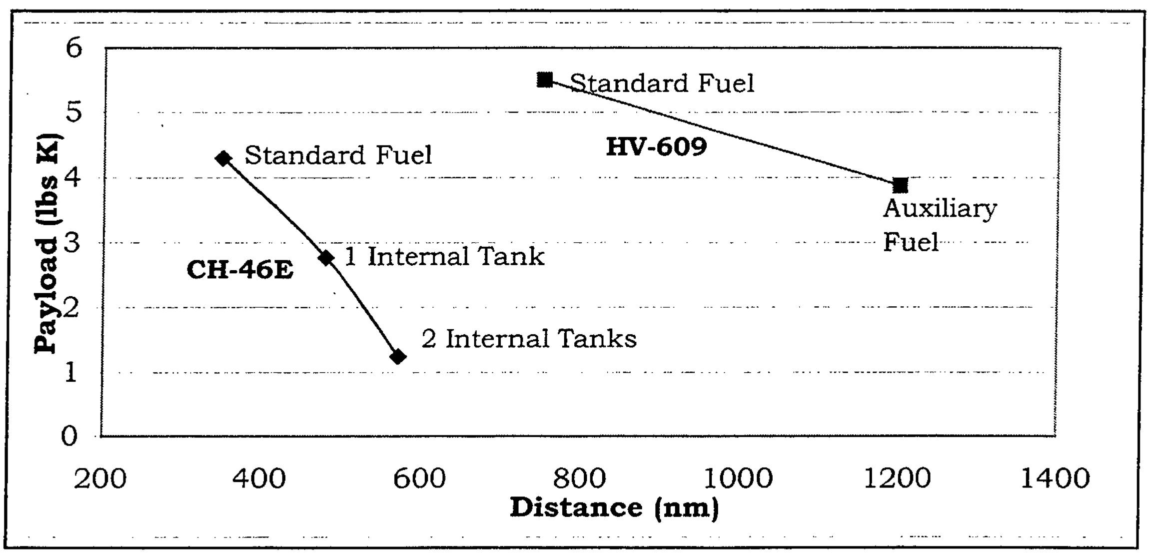

Figure 28. Payload versus Range

Figure 28 illustrates the significance that payload has on the range of the CH-46E used in Alternatives I and II and the HV-609 used in

Alternatives IIIa and IIIb. A disparity between the two platforms exists; the extended range of the CH-46E is 180 nm or 31% less than that of the HV-609 with a standard fuel load. In this regard, Alternatives IIIa and IIIb will always be preferable to Alternatives I and II.

B. OPERATIONAL EFFECTIVENESS ANALYSIS

Operational effectiveness analysis of the four alternatives was conducted using Logical Decisions for Windows (LDW). LDW is a decision support software program that aids in evaluating alternatives for any decision. LDW uses measures that are either numerical or descriptive variables to describe the qualities of the alternatives under consideration. The measures of effectiveness described in the previous section constituted the measures used in the final analysis.

Measures are organized under goals. Goals are broadly defined outcomes that the chosen alternative may impact. Goals and measures are then organized into a hierarchy, with the broadest goal at the top, more specific goals in the middle and quantitative or descriptive measures at the bottom, or lowest level. Goals are used to sum the raw scores of the measures and sub-goals beneath them. The overall ranking of alternatives that LDW produces provides a measure of utility, which can be regarded as an overall measure of effectiveness.

To assess effectiveness, one overall goal was selected, "Best Overall Option." Measures for this goal included two sub-goals: "Best OSA Option" and "Best SAR Option." Each of these sub-goals represents the two basic missions each alternative must fulfill. Each sub-goal had separate measures. Measures for "Best OSA Option" corresponded to the MOEs used for OSA: air travel time, total travel time and landing site requirements. Measures for "Best SAR Option" likewise corresponded to the MOEs used for SAR: range versus time on station and payload versus range. Figure 29 depicts the Best Overall Option goals and measures hierarchy.

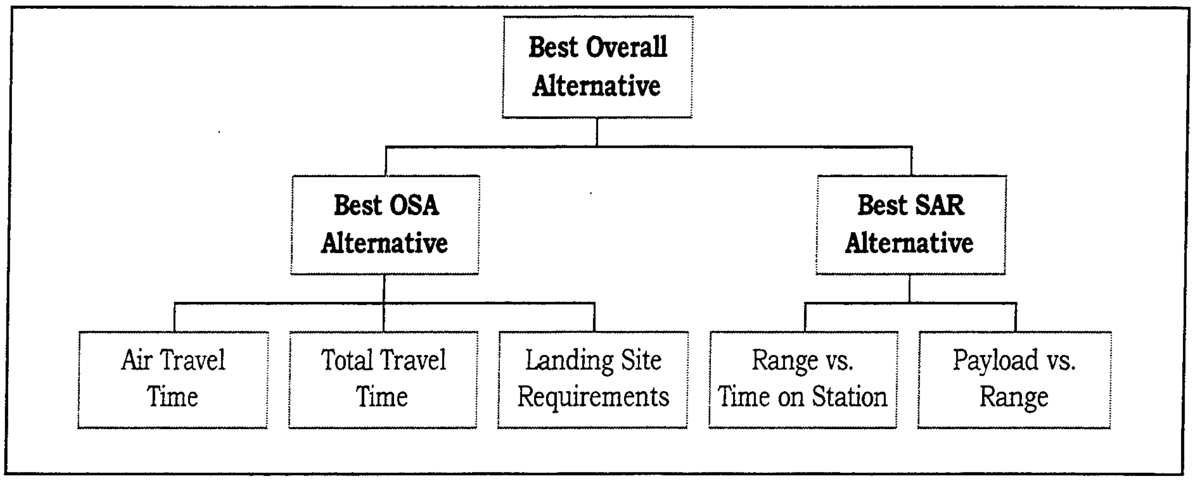

Figure 29. Effectiveness Measures Hierarchy

Once the hierarchy was established, weights were assigned to the subgoals and measures. Both the SAR and OSA missions were considered equally important; the sub-goal weights must sum to 1.0, so each received a weight of 0.5. Similarly, all the measures under each subgoal were equally weighted. Since the measures must sum to the value of the subgoal, OSA measures each received a weighting of 0.167 and SAR measures each received a weighting of 0.25.

The actual analysis of the alternatives was done using the analytical hierarchical process (AHP) function in LDW. AHP allows the user to subjectively rank each alternative against the other alternatives for each measure. This method was chosen because the MOEs used were more qualitative than quantitative and provided an easy means to relationally compare alternatives.

The AHP function of LDW provides nine hierarchical rankings, ranging numerically from "1" to "9" and descriptively from "equal" to "extreme." For each measure selected, an "importance strength" is assigned to each alternative in relation to the other alternatives. Table 8 lists the numerical rankings assigned to each Alternative for each measure of effectiveness and the justification for each relative ranking. These rankings are subjective in nature and reflect the author's interpretation of each alternative's performance relative to the MOEs examined.

Measure: Air Time Travel			scale	justification/rationale
Alternative I	>	Alternative IIIa & IIIb	3	moderate advantage
Alternative II	>	Alternative I	5	strong advantage
Alternative IIIa & IIIb	<	Alternative II	6	very strong advantage
Measure: Total Travel Time				
Alternative I	<	Alternative II	3	moderate advantage
Alternative II	<	Alternative IIIa & IIIb	3	moderate advantage
Alternative IIIa & IIIb	>	Alternative I	5	strong advantage
Measure: Landing Sites				
Alternative I	=	Alternative II	1	equal capacity
Alternative II	<	Alternative IIIa & IIIb	7	demonstrated advantage
Alternative IIIa & IIIb	>	Alternative I	7	demonstrated advantage
Measure: Range vs Time on Station				
Alternative I	=	Alternative II	1	equal capacity
Alternative II	<	Alternative IIIa & IIIb	3	moderate advantage
Alternative IIIa & IIIb	>	Alternative I	3	moderate advantage
Measure: Payload vs Range				
Alternative I	=	Alternative II	1	equal capacity
Alternative II	<	Alternative IIIa & IIIb	5	strong advantage
Alternative IIIa & IIIb	>	Alternative I	5	strong advantage

Table 8. Hierarchical Ranking of Alternatives by Measure of Effectiveness

Table 8 combines Alternatives IIIa and IIIb in the relative assessment because they provide identical capability relative to the MOEs used. While Alternative IIIa and IIIb use different numbers of aircraft, the capability of each aircraft is the same. Based on these hierarchical rankings, LDW assess a utility value for each alternative in each measure, subgoal and goal. Table 9 lists the results of the LDW assessment based on the weights and measures described.

	Best Overall Option	Best OSA Option	Air Travel Time	Total Travel Time	Landing Sites	Best SAR Option	Range vs TOS	Payload vs Range
weight	1.000	0.500	0.167	0.167	0.167	0.500	0.250	0.250
Alternative I C-12 & CH-46E	1.070	1.099	1.992	0.679	0.625	1.042	1.250	0.833
Alternative II C-35 & CH-46E	1.941	2.839	6.370	1.524	0.625	1.042	1.250	0.833
Alternative IIIa HV-609	3.495	3.031	0.819	3.899	4.375	3.958	3.750	4.167
Alternative IIIb HV-609	3.495	3.031	0.819	3.899	4.375	3.958	3.750	4.167

Table 9. Logical Decision for Windows Aircraft Utility Analysis

Each measure, sub-goal and goal has a total utility of "10." This value is user defined and can be any scale, i.e. 0 to 1, 0 to 10, or even 0 to 100. Accordingly, each column in the Table 9 sums to ten. Table 9 indicates that with the measures and relative ranking of alternatives used, Alternatives IIIa and IIIb have the highest overall utility. This indicates that the HV-609 is the best overall option when considering both the OSA and SAR mission. When looking only at the OSA mission, Table 9 indicates that despite the lowest utility for air travel time, the HV-609 is also the best aircraft for the OSA mission, but only marginally. Likewise, Table 9 indicates that the HV-609 is a better option for the SAR mission given the MOEs used in the comparison.

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VI. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSION

The object of cost and operational effectiveness is to identify an alternative that provides the greatest operational effectiveness per dollar spent. This section discusses general and specific conclusions regarding the cost and operational effectiveness of the four alternative force structures examined.

1. General Conclusion

In Chapter IV, net present values of the twenty-year lifecycle costs were estimated for each alternative.. Effectiveness analysis in Chapter V provided a measure of utility or overall effectiveness. Dividing the overall effectiveness or utility by the total cost yields a measure of cost effectiveness for each alternative. This ratio not only indicates how much utility is provided per dollar spent, or how much each unit of utility costs, but also which alternative is the best value. Costs used in Table 10 represent 90th percentile costs for each alternative.

	Cost($M FY98) 90% UCL	Effectiveness (Utility)	$M/Utility	Utility/$100M
Alternative I	565.1	1.070	528	0.189
Alternative II	545.3	1.941	281	0.356
Alternative IIIa	652.1	3.495	187	0.536
Alternative IIIb	596.5	3.495	170	0.587

Table 10. Alternative Force Structure Cost Effectiveness Ratios

Given sufficient resources, the highest marginal benefit, or utility to cost ratio, indicates the preferred alternative. Additionally, if a specific minimum utility value or cost threshhold is given, then the preferred alternative may also be identified. This is more easily visualized if utility is plotted against cost, as seen in Figure 30.

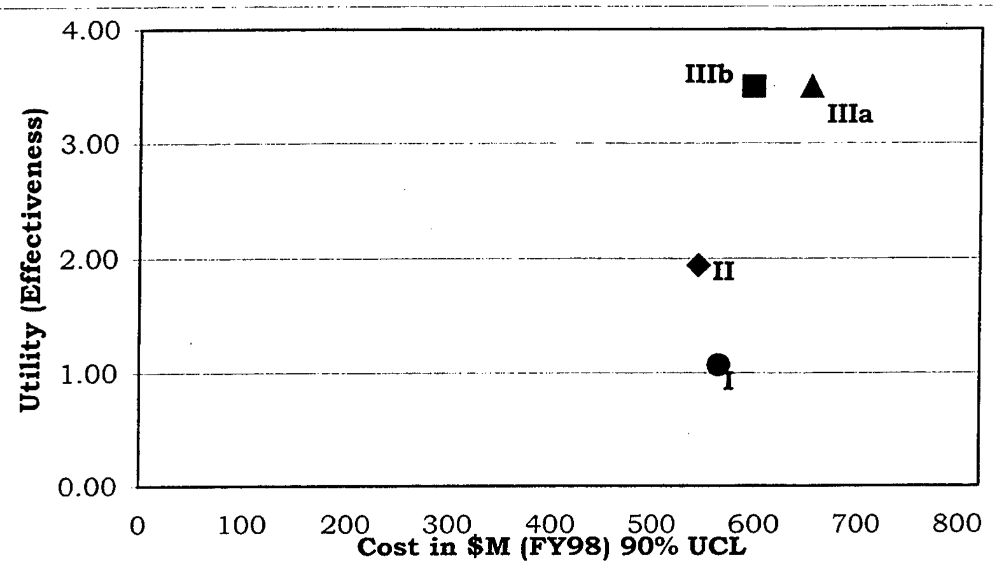


Figure 30. Cost Versus Utility

Given the assumptions in the model, Table 10 and Figure 30 show that Alternative IIIb offers the greatest operational effectiveness per 100 million dollars of lifecycle cost. Alternative IIIb is correspondingly the most cost-effective alternative proposed to fulfill both the OSA and SAR missions. While Alternative IIIb offers the greatest operational effectiveness, the higher utility comes at a much higher cost relative to Alternatives I and II.

2. Specific Conclusions

a. Alternative Aircraft Characteristics

The C-12, C-35 and HV-609 all possess sufficient airspeed, range and seating capacity to adequately fulfill the operational support airlift mission as defined by the Joint Requirement Study and USTRANSCOM. The HV-609 and the CH-46E both possess sufficient speed, range and payload capacity for the Marine Corps' search and rescue mission.

b. Procurement and Conversion Cost

Based on net present value, Alternative I has the lowest procurement and conversion cost of all four alternatives. This will hold true as long as the procurement cost of each C-12 is less than that of the C-35. Alternatives IIIa and IIIb will always have higher procurement costs relative to Alternatives I and II because the procurement price of the HV-609 is substantially greater than the conversion cost for the CH-46E.

c. O&S Costs

With the values used in the analysis, Alternatives IIIa and IIIb have the lowest estimated O&S costs of the alternatives. These alternatives provide lower O&S costs because of the high O&S cost for the CH-46E. The CH-46E operating cost is 390% higher than that of the estimated HV-609 hourly operating cost. Alternative II O&S cost is 10% less than Alternative I O&S cost due to the C-35's lower hourly operating cost.

d. Total Lifecycle Costs

Alternative II has the lowest overall LCC, followed by Alternative I. Alternative I O&S cost constitutes 88% of total LCC at a 90% UCL. Alternative II O&S cost constitutes 80% of total LCC at a 90% UCL. Alternative IIIa O&S cost constitutes 45% of total LCC at a 90% UCL. Alternative IIIb O&S cost constitutes 50% of total LCC at a 90% UCL.

e. Manpower Costs

If contract maintenance is utilized in Alternative IIIa and IIIb, the direct maintenance billets are eliminated, resulting in the savings of 89 Marine billets and a reduction in total force structure requirements.

f. Sensitivity Analysis

Sensitivity analysis of O&S costs indicates that when hourly operating cost of the C-12 are reduced from $1019 to $496, Alternative I replaces Alternative II as the least expensive alternative. Alternative IIIb achieves the lowest lifecycle cost when the HV-609 has an O&S cost reduction from $1121 to $769 per hour. Changing the standard deviation from 10% to 25% had no significant effect on the relative life cycle costs at the 90% UCL.

g. Operational Effectiveness

Alternatives IIIa and IIIb have the highest overall utility using the MOEs of air travel time, total travel time, landing site requirements, range versus time on station, and payload versus range. As a result, given sufficient funding, the HV-609 is the best overall option when considering both the OSA and SAR mission and for each mission individually.

B. RECOMMENDATIONS

The following recommendations are made:

1. Further consideration should be given to examining alternative force structures that utilize multi-role aircraft to fulfill distinctly different tactical and non-tactical missions, particularly tiltrotors.

2. Additional sensitivity analysis should be conducted on the goals and measures used in assessing overall effectiveness to determine the breakeven point for the relative ranking of LDW measures.

3. A detailed sensitivity analysis on the effectiveness of the HV-609 for both the SAR and OSA mission should be conducted using the Logical Decisions for Windows software program to quantify breakeven points in the subgoals and measures weighting.

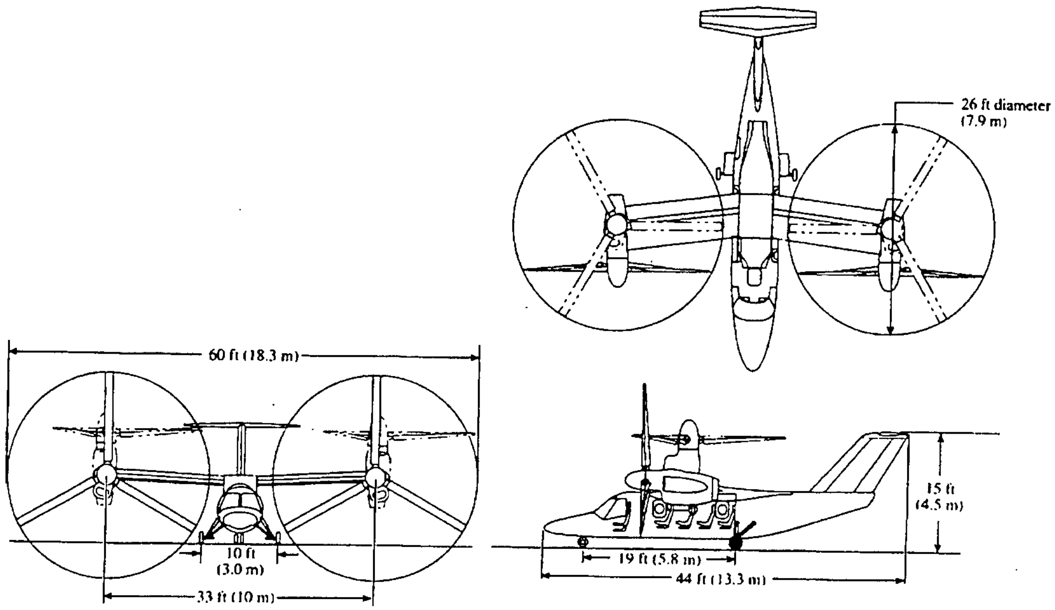
C. AREAS FOR FURTHER RESEARCH

1. Further research should be conducted on specific force structure requirements for the HV-609 to identify other potential factors and economies of scale for Alternative IIIb (two SAR HV-609s for every three SAR helicopters).

2. Further research can be conducted into additional mixes of fixed wing OSA assets and future SAR replacement aircraft beyond the scope of this thesis.

APPENDIX A. AIRCRAFT CHARACTERISTICS

BA-609 Data and characteristics



From Ref. 32

Dimensions, external	
Length overall	44 ft
Width overall	60 ft
Height overall	15.5 ft
Proprotor diameter	26 ft

Performance	
Max cruise speed	275 kts
Standard range	750 nm
Ceiling	25,000 ft
Hoist capacity	600 lbs

Capacities	
Required crew	1-2
Passengers	6-9
Baggage (cubic feet)	50

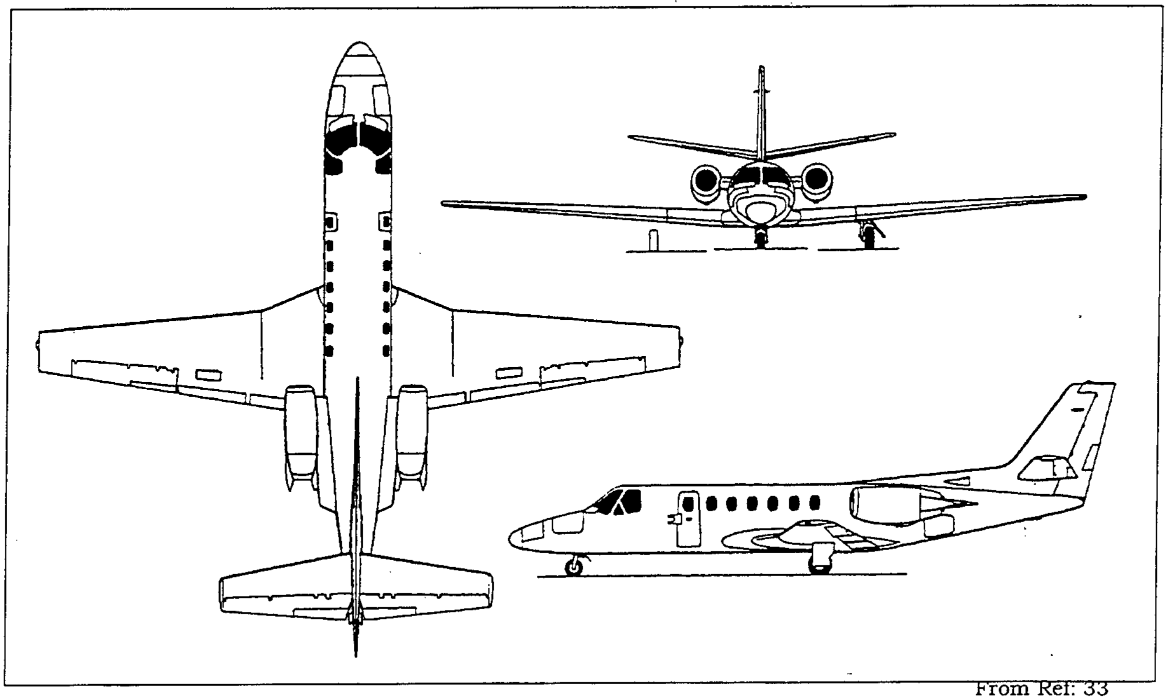
Dimensions, internal	
Cabin length	17 ft 6 in
Width, maximum	5 ft 0.5 in
Height, maximum	5 ft 0 in

Weights		
Max takeoff weight	16,000 lbs	
STOL takeoff weight	18,000 lbs	
Empty weight	10,500 lbs	
Useful load	5,500 lbs	
Auxilliary fuel	1625	lbs

Power plant
(**2**) Pratt & Whitney
PT6A-67C turbo props
(1940 shp each)

From Ref. 32

C-35 Data and Characteristics



From Ref: 33

Dimensions, external		
Length overall	48 ft	10.75 in
Wingspan	52 ft	2 in
Height overall	15 ft	2.4 in

Dimensions, internal		
Cabin length	22 ft	7.25 in
Width, maximum	4 ft	10.75 in
Height, maximum	4 ft	7 in

Weights	
Max takeoff weight	16,630 lbs
Empty weight	9,977 lbs
Useful load	6,653 lbs

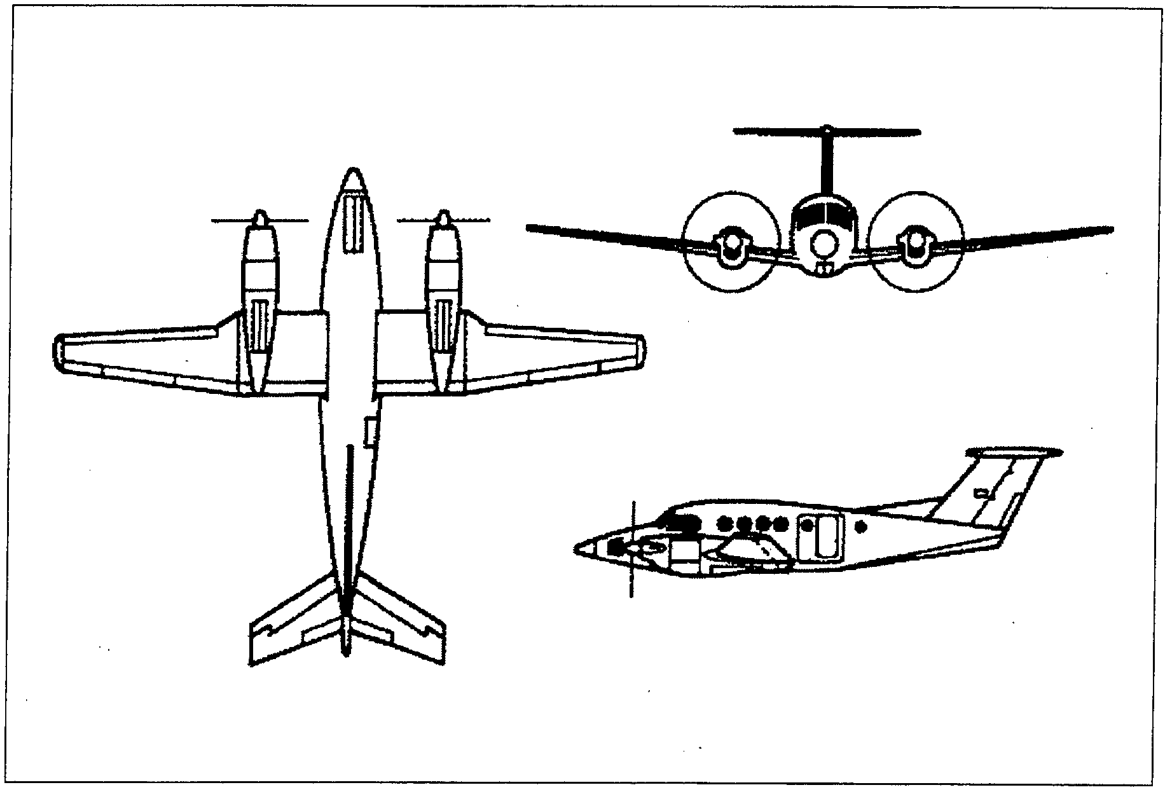
Performance	
Max cruise speed	431 kts
Standard range	2,000 nm
Ceiling	45,000 ft

Power plant
(2) Pratt & Whitney
PW535 turbo fans
(3,360 lbs thrust each)

Capacities	
Required crew	1-2
Passengers	7-8
Baggage (cubic feet)	41

From Ref. 33

C-12 Data and characteristics



From Ref. 34

Dimensions, external		
Length overall	43 ft	10 in
Wingspan	54 ft	6 in
Height overall	15 ft	0 in

Dimensions, internal		
Cabin length	22 ft	0 in
Width, maximum	4 ft	6 in
Height, maximum	4 ft	9 in

Weights	
Max takeoff weight	12,500 lbs
Empty weight	8,192 lbs
Useful load	4,308 lbs

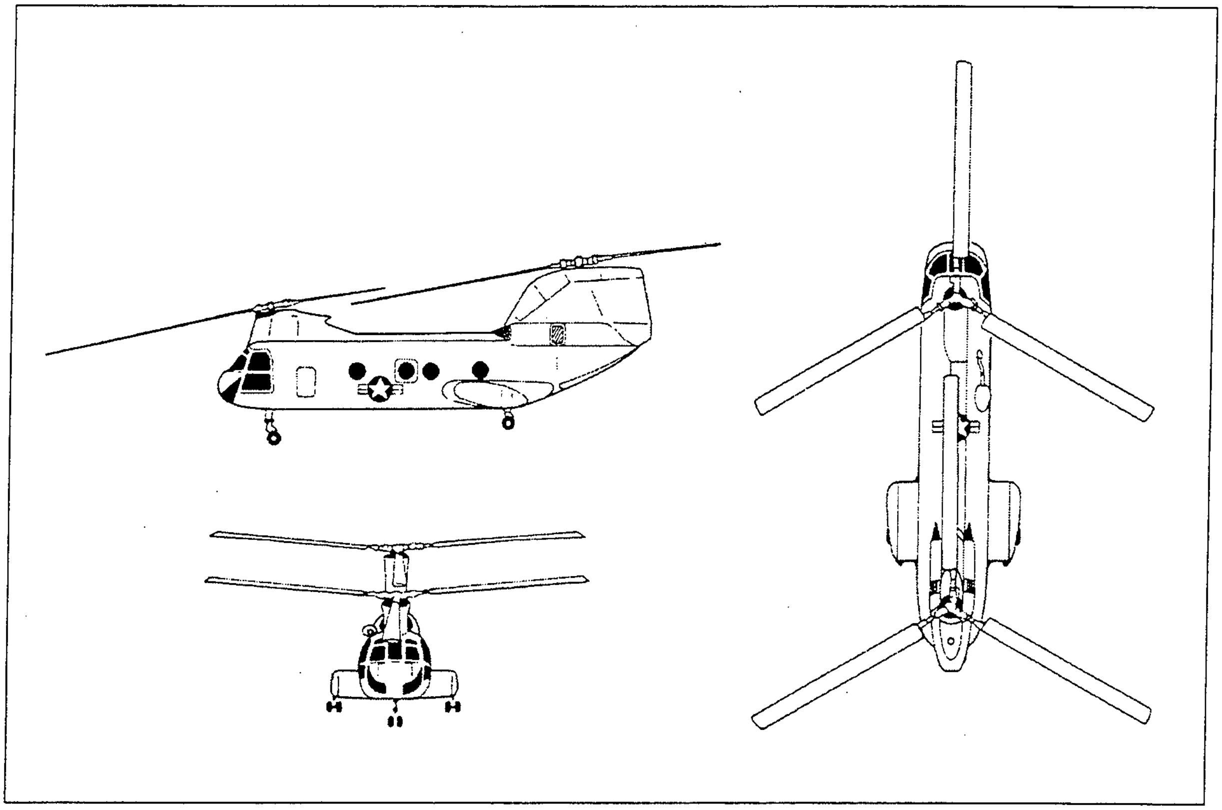
Performance	
Max cruise speed	292 kts
Standard range	1,883 nm
Ceiling	35,000 ft

Power plant
(2) Pratt & Whitney
PT6A-42 turbo props
(850 shp each)

Capacities	
Required crew	2
Passengers	7-9
Baggage (cubic feet)	54

From Ref. 34

CH-46E Data and characteristics



From Ref. 35

Dimensions, external		
Length overall	84 ft	4 in
Width overall	51 ft	0 in
Height overall	16 ft	8 in

Dimensions, internal		
Cabin length	4 ft	2 in
Width, maximum	6 ft	0 in
Height, maximum	6 ft	0 in

Weights	
Max takeoff weight	24,300 lbs
Empty weight	20,000 lbs
Useful load	4,300 lbs
Hoist capacity	600 lbs

Performance	
Max cruise speed	145 kts
Standard range	365 nm
Ceiling	10,000 ft

Power plant
(2) General Electric
T58-GE-16 turboshaft
(1,870 shp each)

Capacities	
Required crew	4-5
Passengers	18
Baggage (cubic feet)	n/a
Auxilliary fuel	470 lbs

From Ref. 35

APPENDIX B. LIFECYCLE COST MODELS

Alternative I LCC Estimate

year	0	1	2	3	4	5	6	7	8
OSA (C-12)									
Number new A/C	4	4	4	2	0	0	0	0	0
Procurement cost ($K)	$16,070.38	$16,070.38	$16,070.38	$8,035.19	$0.00	$0.00	$0.00	$0.00	$0.00
number (old) A/C	10	6	2	0	0	0	0	0	0
Total A/C	14	14	14	14	14	14	14	14	14
Projected total C-12 flt hrs	11417.1	11417.1	11417.1	11417.1	11417.1	11417.1	11417.1	11417.1	11417.1
projected NEW C-12 flt hours	3262.0	6524.1	9786.1	11417.1	11417.1	11417.1	11417.1	11417.1	11417.1
cost per NEW C-12 flt hour	1.019	1.019	1.019	1.019	1.019	1.019	1.019	1.019	1.019
New C-12 flt hour cost	3324.01	6648.02	9972.03	11634.03	11634.03	11634.03	11634.03	11634.03	11634.03
projected OLD C-12 flt hrs	8155.1	4893.0	1631.0	0.0	0.0	0.0	0.0	0.0	0.0
cost per OLD C-12 flt hr ($K)	$1.456	$1.456	$1.456	$1.456	$1.456	$1.456	$1.456	$1.456	$1.456
Old C-12 flight hour cost	$11,873.22	$7,123.93	$2,374.64	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total Alternative I OSA cost ($K)	$31,267.61	$29,842.33	$28,417.05	$19,669.22	$11,634.03	$11,634.03	$11,634.03	$11,634.03	$11,634.03
Present value ($K)	$30,036.13	$28,666.99	$27,297.84	$18,894.55	$11,175.82	$11,175.82	$11,175.82	$11,175.82	$11,175.82
cumulative PV	$30,036.13	$57,574.06	$82,763.99	$99,512.81	$109,029.30	$118,170.98	$126,952.61	$135,388.37	$143,491.89
NPV of OSA program ($K)	**$214,101.26**								
SAR (CH-46E)									
number converted	3	3	3	3	0	0	0	0	0
conversion cost ($K)	$597.85	$597.85	$597.85	$597.85	$0.00	$0.00	$0.00	$0.00	$0.00
number HH-46D	9	6	3	0					
number HH-1N	0								
total SAR Aircraft	12	12	12	12	12	12	12	12	12
projected total SAR flt hrs	3285.8	3285.8	3285.8	3285.8	3285.8	3285.8	3285.8	3285.8	3285.8
CH-46E SAR hours	821.4	1642.9	2464.3	3285.8	3285.8	3285.8	3285.8	3285.8	3285.8
cost per CH-46E flt hr ($K)	5.49	5.49	5.49	5.49	5.49	5.49	5.49	5.49	5.49
CH-46E SAR hour cost	4513.83	9027.67	13541.50	18055.33	18055.33	18055.33	18055.33	18055.33	18055.33
HH-46D SAR hours	2464.3	1642.9	821.4	0.0	0.0	0.0	0.0	0.0	0.0
cost per HH-46D flt hr ($K)	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35
HH-46D SAR flt hr cost	$15,659	$10,440	$5,220	$0	$0	$0	$0	$0	$0
Total Alt. I SAR cost ($K)	$20,770.98	$20,065.05	$19,359.12	$18,653.19	$18,055.33	$18,055.33	$18,055.33	$18,055.33	$18,055.33
Present value ($K)	$19,952.91	$19,274.78	$18,596.65	$17,918.53	$17,344.22	$17,344.22	$17,344.22	$17,344.22	$17,344.22
cumulative PV	$19,952.91	$38,468.55	$55,629.19	$71,512.83	$86,281.85	$100,469.20	$114,097.77	$127,189.58	$139,765.77
NPV of SAR program ($K)	**$249,347.33**								
Total cost of Alternative I	$52,038.59	$49,907.38	$47,776.17	$38,322.41	$29,689.37	$29,689.37	$29,689.37	$29,689.37	$29,689.37
NPV of Alternative I ($K)	**$463,448.59**								
		OSA	SAR						
NPV of Proc. and Conv. Cost	**$53,519.47**	**$51,354.42**	**$2,165.04**						
NPV of O&S Cost	**$409,929.13**	**$14,598.69**	**$247,182.29**						

Alternative I LCC Estimate

9	10	11	12	13	14	15	16	17	18	19
0	0	0	0	0	0	0	0	0	0	0
$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
0	0	0	0	0	0	0	0	0	0	0
14	14	14	14	14	14	14	14	14	14	14
11417.1	11417.1	11417.1	11417.1	11417.1	11417.1	11417.1	11417.1	11417.1	11417.1	11417.1
11417.1	11417.1	11417.1	11417.1	11417.1	11417.1	11417.1	11417.1	11417.1	11417.1	11417.1
1.019	1.019	1.019	1.019	1.019	1.019	1.019	1.019	1.019	1.019	1.019
11634.03	11634.03	11634.03	11634.03	11634.03	11634.03	11634.03	11634.03	11634.03	11634.03	11634.03
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$1.456	$1.456	$1.456	$1.456	$1.456	$1.456	$1.456	$1.456	$1.456	$1.456	$1.456
$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
$11,634.03	$11,634.03	$11,634.03	$11,634.03	$11,634.03	$11,634.03	$11,634.03	$11,634.03	$11,634.03	$11,634.03	$11,634.03
$11,175.82	$11,175.82	$11,175.82	$11,175.82	$11,175.82	$11,175.82	$11,175.82	$11,175.82	$11,175.82	$11,175.82	$11,175.82
$151,276.26	$158,754.03	$165,937.29	$172,837.63	$179,466.21	$185,833.71	$191,950.43	$197,826.25	$203,470.64	$208,892.73	$214,101.26
0	0	0	0	0	0	0	0	0	0	0
$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
12	12	12	12	12	12	12	12	12	12	12
3285.8	3285.8	3285.8	3285.8	3285.8	3285.8	3285.8	3285.8	3285.8	3285.8	3285.8
3285.8	3285.8	3285.8	3285.8	3285.8	3285.8	3285.8	3285.8	3285.8	3285.8	3285.8
5.49	5.49	5.49	5.49	5.49	5.49	5.49	5.49	5.49	5.49	5.49
18055.33	18055.33	18055.33	18055.33	18055.33	18055.33	18055.33	18055.33	18055.33	18055.33	18055.33
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35
$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
$18,055.33	$18,055.33	$18,055.33	$18,055.33	$18,055.33	$18,055.33	$18,055.33	$18,055.33	$18,055.33	$18,055.33	$18,055.33
$17,344.22	$17,344.22	$17,344.22	$17,344.22	$17,344.22	$17,344.22	$17,344.22	$17,344.22	$17,344.22	$17,344.22	$17,344.22
$151,846.64	$163,451.70	$174,599.69	$185,308.62	$195,595.78	$205,477.77	$214,970.56	$224,089.47	$232,849.23	$241,263.99	$249,347.33
$29,689.37	$29,689.37	$29,689.37	$29,689.37	$29,689.37	$29,689.37	$29,689.37	$29,689.37	$29,689.37	$29,689.37	$29,689.37

ALTERNATIVE II LCC Estimate

year	0	1	2	3	4	5	6	7	8	9	10
OSA (C-35)											
Number new (C-35) A/C	4	4	4	2	0	0	0	0	0	0	0
Procurement cost ($K)	$27,088.95	$27,088.95	$27,088.95	$13,544.48	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
number C-12 A/C	10	6	2	0	0	0	0	0	0	0	0
Total OSA A/C	14	14	14	14	14	14	14	14	14	14	14
Projected total OSA flt hrs	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1
Projected total C-12 flt hrs	8,155.1	4,893.0	1,631.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cost per C-12 flt hr	$1.456	$1.456	$1.456	$1.456	$1.456	$1.456	$1.456	$1.456	$1.456	$1.456	$1.456
Total C-12 flt hr cost	$11,873	$7,124	$2,375	$0	$0	$0	$0	$0	$0	$0	$0
Projected total C-35 flt hrs	3,262.0	6,524.1	9,786.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1
cost per C-35 flt hr	$0.658	$0.658	$0.658	$0.658	$0.658	$0.658	$0.658	$0.658	$0.658	$0.658	$0.658
Total C-35 flt hr cost	$2,145	$4,290	$6,435	$7,508	$7,508	$7,508	$7,508	$7,508	$7,508	$7,508	$7,508
Other costs											
Site Activation Cost)($K)	$308	$308	$308	$154	$0	$0	$0	$0	$0	$0	$0
Total OSA cost ($K)	$41,415.34	$38,811.07	$36,206.80	$21,206.11	$7,507.56	$7,507.56	$7,507.56	$7,507.56	$7,507.56	$7,507.56	$7,507.56
Present value ($K)	$39,784.19	$37,282.49	$34,780.79	$20,370.91	$7,211.88	$7,211.88	$7,211.88	$7,211.88	$7,211.88	$7,211.88	$7,211.88
cumulative PV	$39,784.19	$75,598.30	$107,693.35	$125,750.87	$131,891.96	$137,791.18	$143,458.06	$148,901.74	$154,131.03	$159,154.36	$163,979.85
NPV of OSA (C-35) program	$199,695.99										
SAR (CH-46E)											
number converted	3	3	3	3	0	0	0	0	0	0	0
conversion cost ($K)	$597.85	$597.85	$597.85	$597.85	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
number HH-46D	9	6	3	0							
number HH-1N	0										
total SAR Aircraft	12	12	12	12	12	12	12	12	12	12	12
projected total SAR flt hrs	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8
CH-46E SAR hours	821.4	1,642.9	2,464.3	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8
cost per CH-46E flt hr	$5.49	$5.49	$5.49	$5.49	$5.49	$5.49	$5.49	$5.49	$5.49	$5.49	$5.49
CH-46E SAR flight hour costs	$4,513.83	$9,027.67	$13,541.50	$18,055.33	$18,055.33	$18,055.33	$18,055.33	$18,055.33	$18,055.33	$18,055.33	$18,055.33
HH-46D SAR hours	2,464.3	1,642.9	821.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
cost per HH-46D flt hr	$6.35	$6.35	$6.35	$6.35	$6.35	$6.35	$6.35	$6.35	$6.35	$6.35	$6.35
HH-46D SAR flt hr cost	$15,659.29	$10,439.53	$5,219.76	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total SAR cost ($K)	$20,770.98	$20,065.05	$19,359.12	$18,653.19	$18,055.33	$18,055.33	$18,055.33	$18,055.33	$18,055.33	$18,055.33	$18,055.33
Present value ($K)	$19,952.91	$19,274.78	$18,596.65	$17,918.53	$17,344.22	$17,344.22	$17,344.22	$17,344.22	$17,344.22	$17,344.22	$17,344.22
cumulative PV	$19,952.91	$38,468.55	$55,629.19	$71,512.83	$86,281.85	$100,469.20	$114,097.77	$127,189.58	$139,765.77	$151,846.64	$163,451.70
NPV of SAR (CH-46E) program ($K)	$249,347.33										
Total cost of this option	$62,186.32	$58,876.12	$55,565.92	$39,859.30	$25,562.90	$25,562.90	$25,562.90	$25,562.90	$25,562.90	$25,562.90	$25,562.90
NPV of Alternative II	$449,043.33										
NPV of Proc. and Conv. Cost	$88,730.36										
NPV of O&S Cost	$360,312.97										

ALTERNATIVE II LCC Estimate

11	12	13	14	15	16	17	18	19
0	0	0	0	0	0	0	0	0
$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
0	0	0	0	0	0	0	0	0
14	14	14	14	14	14	14	14	14
11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$1.456	$1.456	$1.456	$1.456	$1.456	$1.456	$1.456	$1.456	$1.456
$0	$0	$0	$0	$0	$0	$0	$0	$0
11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1
$0.658	$0.658	$0.658	$0.658	$0.658	$0.658	$0.658	$0.658	$0.658
$7,508	$7,508	$7,508	$7,508	$7,508	$7,508	$7,508	$7,508	$7,508
$0	$0	$0	$0	$0	$0	$0	$0	$0
$7,507.56	$7,507.56	$7,507.56	$7,507.56	$7,507.56	$7,507.56	$7,507.56	$7,507.56	$7,507.56
$7,211.88	$7,211.88	$7,211.88	$7,211.88	$7,211.88	$7,211.88	$7,211.88	$7,211.88	$7,211.88
$168,615.28	$173,068.14	$177,345.63	$181,454.65	$185,401.83	$189,193.56	$192,835.94	$196,334.87	$199,695.99
0	0	0	0	0	0	0	0	0
$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
12	12	12	12	12	12	12	12	12
3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8
3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8
$5.49	$5.49	$5.49	$5.49	$5.49	$5.49	$5.49	$5.49	$5.49
$18,055.33	$18,055.33	$18,055.33	$18,055.33	$18,055.33	$18,055.33	$18,055.33	$18,055.33	$18,055.33
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
$6.35	$6.35	$6.35	$6.35	$6.35	$6.35	$6.35	$6.35	$6.35
$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
$18,055.33	$18,055.33	$18,055.33	$18,055.33	$18,055.33	$18,055.33	$18,055.33	$18,055.33	$18,055.33
$17,344.22	$17,344.22	$17,344.22	$17,344.22	$17,344.22	$17,344.22	$17,344.22	$17,344.22	$17,344.22
$174,599.69	$185,308.62	$195,595.78	$205,477.77	$214,970.56	$224,089.47	$232,849.23	$241,263.99	$249,347.33
$25,562.90	$25,562.90	$25,562.90	$25,562.90	$25,562.90	$25,562.90	$25,562.90	$25,562.90	$25,562.90

ALTERNATIVE IIIa LCC Estimate

year	0	1	2	3	4	5	6	7	8
OSA (HV-609)									
New HV-609	4	4	4	2	0	0	0	0	
Procurement cost	$46,920.82	$46,920.82	$46,920.82	$23,460.41	$0.00	$0.00	$0.00	$0.00	$0.00
number C-12 remaining	10	6	2	0	0	0			
Total OSA aircraft	14	14	14	14	14	14	14	14	14
Projected OSA flight hours	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1
Projected C-12 flt hrs	8,155.1	4,893.0	1,631.0	0.0	0.0	0.0	0.0	0.0	0.0
cost per C-12 flt hr ($K)	1.456	1.456	1.456	1.456	1.456	1.456	1.456	1.456	1.456
C-12 flt hour costs	11,873.22	7,123.93	2,374.64	0.00	0.00	0.00	0.00	0.00	0.00
Projected HV-609 flt hrs	3,262.0	6,524.1	9,786.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1
cost per HV-609 flt hr ($K)	1.121	1.121	1.121	1.121	1.121	1.121	1.121	1.121	1.121
HV-609 flt hour cost	$3,657	$7,313	$10,970	$12,799	$12,799	$12,799	$12,799	$12,799	$12,799
other costs									
site activation costs ($K)	$308.15	$308.15	$308.15	$154.07	$0.00	$0.00	$0.00	$0.00	$0.00
Total OSA cost ($K)	62,759	61,666	60,574	36,413	12,799	12,799	12,799	12,799	12,799
Present value ($K)	60,287	59,238	58,188	34,979	12,295	12,295	12,295	12,295	12,295
cumulative PV	60,287	117,192	170,887	201,893	212,362	222,419	232,080	241,360	250,274
NPV of OSA program	**$327,951.72**								
SAR									
New HV-609	3	3	3	3					
Procurement cost	$43,988.27	$43,988.27	$43,988.27	$43,988.27					
number H-46 remaining	9	6	3	0					
number H-1 remaining	0	0	0	0	0				
total SAR Aircraft	12	12	12	12	12	12	12	12	12
projected total SAR flt hrs	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8
projected H-46 flt hrs	2,464.3	1,642.9	821.4	0.0	0.0	0.0	0.0	0.0	0.0
cost per H-46 flt hr ($K)	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35
HH-46 SAR flight hour cost	$15,659.29	$10,439.53	$5,219.76	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
projected HV-609 flt hrs	821.4	1,642.9	2,464.3	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8
cost per HV-609 flt hr ($K)	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
HV-609 SAR flight hour cost	$920.84	$1,841.68	$2,762.52	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36
Total SAR costs ($K)	$60,568.40	$56,269.48	$51,970.56	$47,671.63	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36
Present value ($K)	$58,182.90	$54,053.29	$49,923.68	$45,794.07	$3,538.29	$3,538.29	$3,538.29	$3,538.29	$3,538.29
cumulative PV	$58,182.90	$110,107.30	$156,175.92	$196,769.47	$199,782.41	$202,676.69	$205,456.98	$208,127.76	$210,693.35
NPV of SAR program ($K)	**$233,048.44**								
Total cost Alternative III	$123,327.33	$117,935.86	$112,544.38	$84,084.70	$16,481.94	$16,481.94	$16,481.94	$16,481.94	$16,481.94
NPV of Alternative III ($K)	**$561,000.17**								
NPV of Proc. and Conv. Cost	**$309,237.14**								
NPV of O&S Cost	**$251,763.02**								

ALTERNATIVE IIIa LCC Estimate

9	10	11	12	13	14	15	16	17	18	19
$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
14	14	14	14	14	14	14	14	14	14	14
11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.456	1.456	1.456	1.456	1.456	1.456	1.456	1.456	1.456	1.456	1.456
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1
1.121	1.121	1.121	1.121	1.121	1.121	1.121	1.121	1.121	1.121	1.121
$12,799	$12,799	$12,799	$12,799	$12,799	$12,799	$12,799	$12,799	$12,799	$12,799	$12,799
$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
12,799	12,799	12,799	12,799	12,799	12,799	12,799	12,799	12,799	12,799	12,799
12,295	12,295	12,295	12,295	12,295	12,295	12,295	12,295	12,295	12,295	12,295
258,838	267,064	274,967	282,558	289,850	296,855	303,584	310,048	316,257	322,222	327,952
12	12	12	12	12	12	12	12	12	12	12
3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35
$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8
1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36
$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36
$3,538.29	$3,538.29	$3,538.29	$3,538.29	$3,538.29	$3,538.29	$3,538.29	$3,538.29	$3,538.29	$3,538.29	$3,538.29
$213,157.90	$215,525.38	$217,799.62	$219,984.28	$222,082.90	$224,098.87	$226,035.44	$227,895.73	$229,682.76	$231,399.41	$233,048.44
$16,481.94	$16,481.94	$16,481.94	$16,481.94	$16,481.94	$16,481.94	$16,481.94	$16,481.94	$16,481.94	$16,481.94	$16,481.94

ALTERNATIVE IIIb LCC Estimate

year	0	1	2	3	4	5	6	7	8
OSA (HV-609)									
New HV-609	4	4	4	2	0	0	0	0	
Procurement cost	$46,920.82	$46,920.82	$46,920.82	$23,460.41	$0.00	$0.00	$0.00	$0.00	$0.00
number C-12 remaining	10	6	2	0	0	0			
Total OSA aircraft	14	14	14	14	14	14	14	14	14
Projected OSA flight hours	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1
Projected C-12 flt hrs	8,155.1	4,893.0	1,631.0	0.0	0.0	0.0	0.0	0.0	0.0
cost per C-12 flt hr ($K)	1.456	1.456	1.456	1.456	1.456	1.456	1.456	1.456	1.456
C-12 flt hour costs	11,873.22	7,123.93	2,374.64	0.00	0.00	0.00	0.00	0.00	0.00
Projected HV-609 flt hrs	3,262.0	6,524.1	9,786.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1
cost per HV-609 flt hr ($K)	1.121	1.121	1.121	1.121	1.121	1.121	1.121	1.121	1.121
HV-609 flt hour cost	$3,657	$7,313	$10,970	$12,799	$12,799	$12,799	$12,799	$12,799	$12,799
other costs									
site activation costs ($K)	$308.15	$308.15	$308.15	$154.07	$0.00	$0.00	$0.00	$0.00	$0.00
Total OSA cost ($K)	62,759	61,666	60,574	36,413	12,799	12,799	12,799	12,799	12,799
Present value ($K)	60,287	59,238	58,188	34,979	12,295	12,295	12,295	12,295	12,295
cumulative PV	60,287	117,192	170,887	201,893	212,362	222,419	232,080	241,360	250,274
NPV of OSA program	**$327,951.72**								
SAR									
New HV-609	2	2	2	2					
Procurement cost	$29,325.51	$29,325.51	$29,325.51	$29,325.51					
number H-46 remaining	9	6	3	0					
number H-1 remaining	0	0	0	0	0				
total SAR Aircraft	11	10	9	8	8	8	8	8	8
projected total SAR flt hrs	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8
projected H-46 flt hrs	2,688.4	1,971.5	1,095.3	0.0	0.0	0.0	0.0	0.0	0.0
cost per H-46 flt hr ($K)	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35
HH-46 SAR flight hour cost	$17,082.86	$12,527.43	$6,959.69	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
projected HV-609 flt hrs	597.4	1,314.3	2,190.5	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8
cost per HV-609 flt hr ($K)	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
HV-609 SAR flight hour cost	$669.70	$1,473.34	$2,455.57	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36
Total SAR costs ($K)	$47,078.08	$43,326.29	$38,740.77	$33,008.88	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36
Present value ($K)	$45,223.90	$41,619.88	$37,214.96	$31,708.81	$3,538.29	$3,538.29	$3,538.29	$3,538.29	$3,538.29
cumulative PV	$45,223.90	$85,204.57	$119,545.82	$147,653.68	$150,666.62	$153,560.90	$156,341.19	$159,011.97	$161,577.56
NPV of SAR program ($K)	**$183,932.65**								
Total cost Alternative III	$109,837.01	$104,992.67	$99,314.60	$69,421.94	$16,481.94	$16,481.94	$16,481.94	$16,481.94	$16,481.94
NPV of Alternative IIIb ($K)	**$511,884.38**								
NPV of Proc. and Conv. Cost	**$256,138.07**								
NPV of O&S Cost	**$255,746.31**								

ALTERNATIVE IIIb LCC Estimate

	9	10	11	12	13	14	15	16	17	18	19
	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	14	14	14	14	14	14	14	14	14	14	14
	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1.456	1.456	1.456	1.456	1.456	1.456	1.456	1.456	1.456	1.456	1.456
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1	11,417.1
	1.121	1.121	1.121	1.121	1.121	1.121	1.121	1.121	1.121	1.121	1.121
	$12,799	$12,799	$12,799	$12,799	$12,799	$12,799	$12,799	$12,799	$12,799	$12,799	$12,799
	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	12,799	12,799	12,799	12,799	12,799	12,799	12,799	12,799	12,799	12,799	12,799
	12,295	12,295	12,295	12,295	12,295	12,295	12,295	12,295	12,295	12,295	12,295
	258,838	267,064	274,967	282,558	289,850	296,855	303,584	310,048	316,257	322,222	327,952
	8	8	8	8	8	8	8	8	8	8	8
	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35	6.35
	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8	3,285.8
	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12	1.12
	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36
	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36	$3,683.36
	$3,538.29	$3,538.29	$3,538.29	$3,538.29	$3,538.29	$3,538.29	$3,538.29	$3,538.29	$3,538.29	$3,538.29	$3,538.29
	$164,042.11	$166,409.59	$168,683.83	$170,868.49	$172,967.11	$174,983.08	$176,919.65	$178,779.95	$180,566.97	$182,283.62	$183,932.65
	$16,481.94	$16,481.94	$16,481.94	$16,481.94	$16,481.94	$16,481.94	$16,481.94	$16,481.94	$16,481.94	$16,481.94	$16,481.94

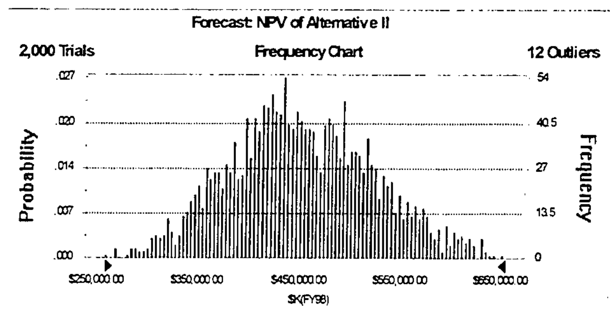
APPENDIX C. CRYSTAL BALL FORECAST DATA

Crystal Ball Report
Simulation started on 3/15/00 at 18:43:53
Simulation stopped on 3/15/00 at 18:46:46

Forecast: NPV of Alternative II **Alternative II LCC Model**

Summary:

Display Range is from $250,000.00 to $650,000.00 $K(FY98)
Entire Range is from $248,765.71 to $706,127.75 $K(FY98)
After 2,000 Trials, the Std. Error of the Mean is $1,651.35



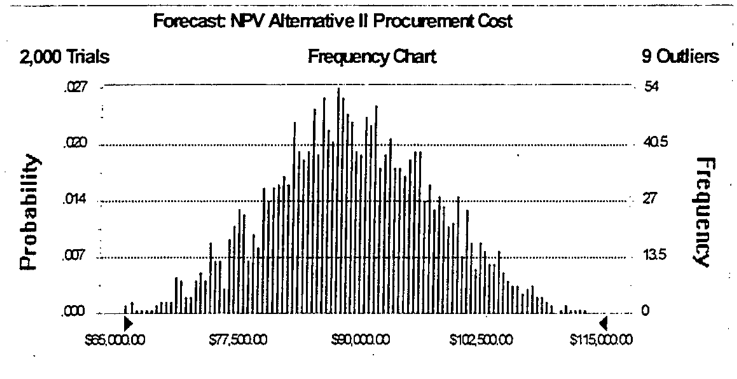
Percentiles:

Percentile	$K(FY98)
0%	$248,765.71
10%	$353,511.56
20%	$384,483.85
30%	$406,511.11
40%	$423,930.97
50%	$442,529.05
60%	$464,662.73
70%	$486,198.63
80%	$510,698.19
90%	$545,308.43
100%	$706,127.75

Forecast: NPV Alternative II Procurement Cost **Alternative II LCC Model**

Summary:

Display Range is from $65,000.00 to $115,000.00
Entire Range is from $58,965.96 to $118,696.31
After 2,000 Trials, the Std. Error of the Mean is $193.03



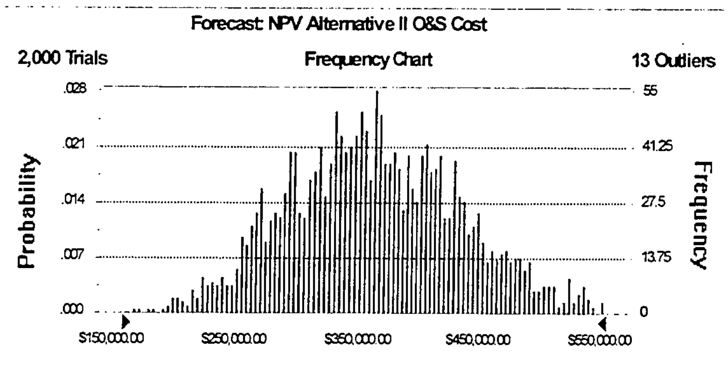
Percentiles:

Percentile	Value
0%	$58,965.96
10%	$77,210.33
20%	$81,258.85
30%	$83,955.76
40%	$86,136.73
50%	$88,209.59
60%	$90,503.11
70%	$93,036.36
80%	$95,842.63
90%	$99,818.62
100%	$118,696.31

Forecast: NPV Alternative II O&S Cost

Summary:

Display Range is from $150,000.00 to $550,000.00
Entire Range is from $158,350.56 to $626,595.69
After 2,000 Trials, the Std. Error of the Mean is $1,641.60

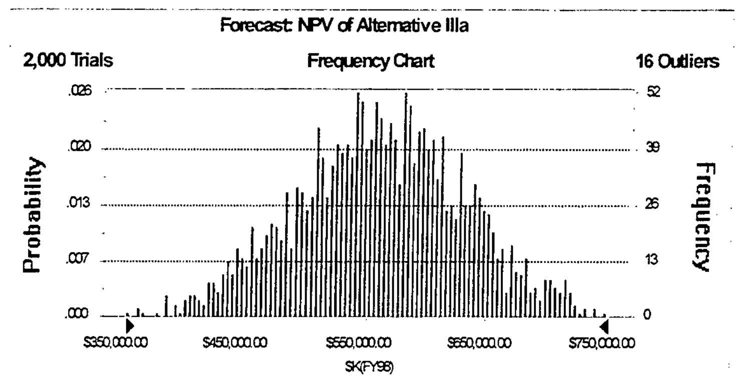


Percentiles:

Percentile	Value
0%	$158,350.56
10%	$264,489.98
20%	$292,895.76
30%	$318,489.24
40%	$336,721.92
50%	$355,451.29
60%	$374,351.74
70%	$398,605.42
80%	$422,151.46
90%	$456,654.42
100%	$626,595.69

Summary:

Display Range is from $350,000.00 to $750,000.00 $K(FY98)
Entire Range is from $345,046.95 to $827,291.55 $K(FY98)
After 2,000 Trials, the Std. Error of the Mean is $1,608.45



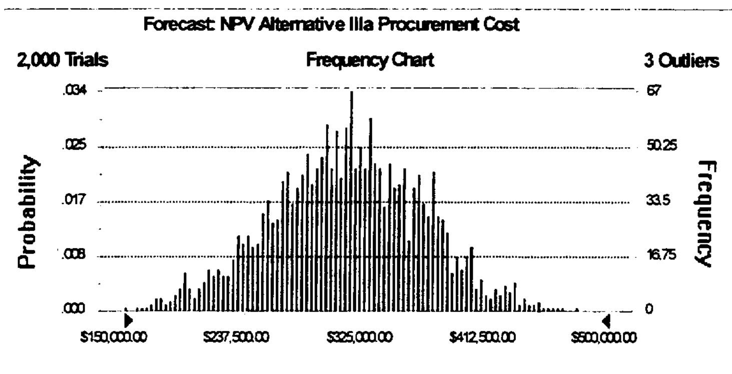
Percentiles:

Percentile	$K(FY98)
0%	$345,046.95
10%	$468,788.79
20%	$502,404.59
30%	$525,490.74
40%	$543,742.04
50%	$561,864.22
60%	$581,246.87
70%	$600,206.79
80%	$624,886.12
90%	$652,143.29
100%	$827,291.55

Forecast: NPV Alternative IIIa Procurement Cost **Alternative IIIa LCC Model**

Summary:

Display Range is from $150,000.00 to $500,000.00
Entire Range is from $138,443.01 to $504,980.89
After 2,000 Trials, the Std. Error of the Mean is $1,225.86



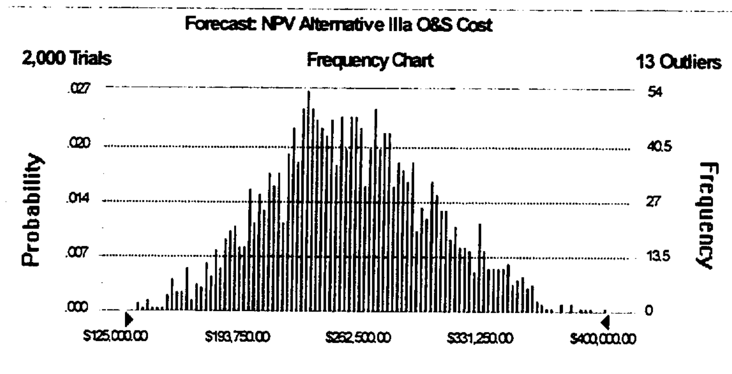
Percentiles:

Percentile	Value
0%	$138,443.01
10%	$238,443.68
20%	$264,743.87
30%	$281,517.57
40%	$296,673.59
50%	$310,985.16
60%	$324,387.43
70%	$339,819.80
80%	$358,919.42
90%	$379,299.26
100%	$504,980.89

Forecast: NPV Alternative IIIa O&S Cost **Alternative IIIa LCC Model**

Summary:

Display Range is from $125,000.00 to $400,000.00
Entire Range is from $96,055.81 to $429,874.87
After 2,000 Trials, the Std. Error of the Mean is $1,069.06



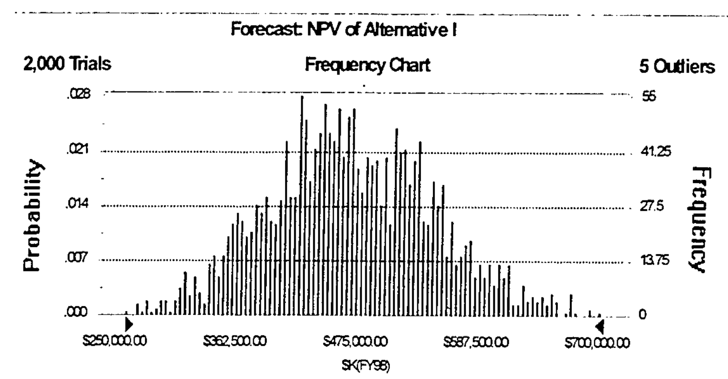
Percentiles:

Percentile	Value
0%	$96,055.81
10%	$192,894.16
20%	$212,079.56
30%	$226,499.75
40%	$237,768.66
50%	$250,600.85
60%	$263,402.17
70%	$276,111.26
80%	$293,428.17
90%	$315,912.86
100%	$429,874.87

Forecast: NPV of Alternative I **Alternative I LCC Model**

Summary:

Display Range is from $250,000.00 to $700,000.00 $K(FY98)
Entire Range is from $242,801.16 to $737,297.81 $K(FY98)
After 2,000 Trials, the Std. Error of the Mean is $1,769.45



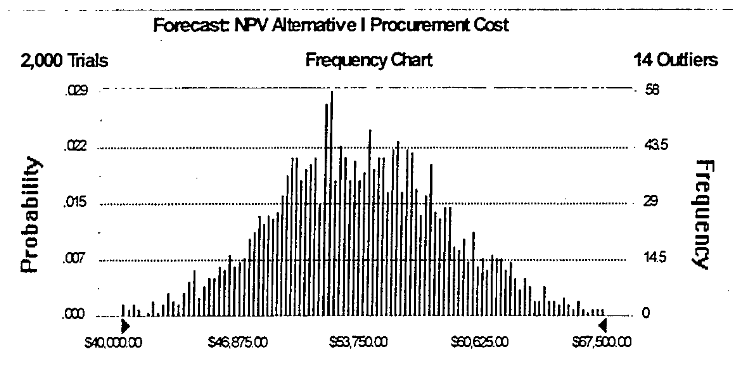
Percentiles:

Percentile	$K(FY98)
0%	$242,801.16
10%	$360,299.69
20%	$396,151.03
30%	$418,969.42
40%	$439,081.70
50%	$458,153.22
60%	$480,442.06
70%	$505,822.21
80%	$528,184.25
90%	$565,115.69
100%	$737,297.81

Forecast: NPV Alternative I Procurement Cost **Alternative I LCC Model**

Summary:

Display Range is from $40,000.00 to $67,500.00
Entire Range is from $33,726.81 to $72,108.18
After 2,000 Trials, the Std. Error of the Mean is $114.74



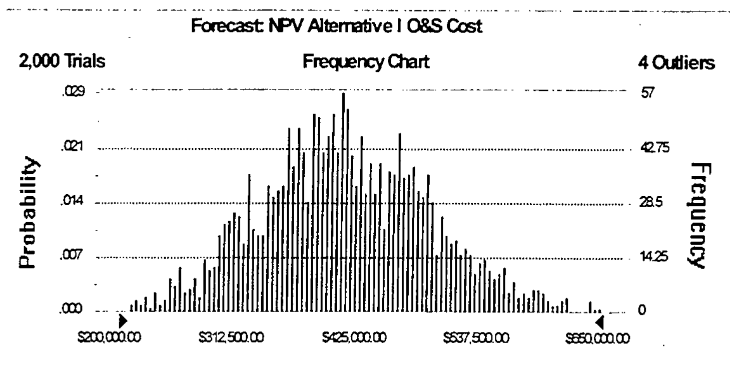
Percentiles:

Percentile	Value
0%	$33,726.81
10%	$47,077.12
20%	$49,193.94
30%	$50,592.72
40%	$51,837.55
50%	$53,251.39
60%	$54,632.35
70%	$56,057.07
80%	$57,603.30
90%	$60,136.25
100%	$72,108.18

Forecast: NPV Alternative I O&S Cost **Alternative I LCC Model**

Summary:

Display Range is from $200,000.00 to $650,000.00
Entire Range is from $186,975.65 to $685,931.38
After 2,000 Trials, the Std. Error of the Mean is $1,766.24

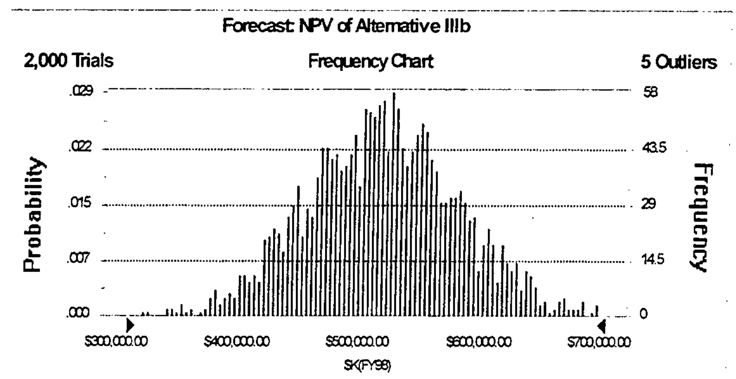


Percentiles:

Percentile	Value
0%	$186,975.65
10%	$306,371.07
20%	$342,056.08
30%	$365,666.12
40%	$386,542.10
50%	$405,345.32
60%	$425,458.34
70%	$453,051.34
80%	$476,695.00
90%	$511,739.30
100%	$685,931.38

Summary:

Display Range is from $300,000.00 to $700,000.00 $K(FY98)
Entire Range is from $315,379.20 to $739,904.69 $K(FY98)
After 2,000 Trials, the Std. Error of the Mean is $1,428.36



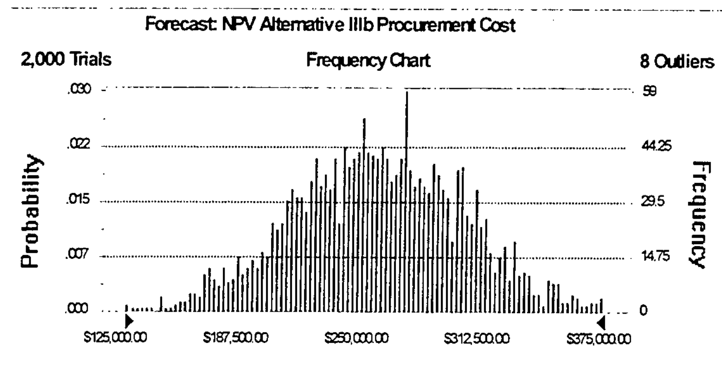
Percentiles:

Percentile	$K(FY98)
0%	$315,379.20
10%	$431,595.73
20%	$459,522.26
30%	$478,867.40
40%	$498,050.31
50%	$512,956.64
60%	$528,250.97
70%	$546,300.38
80%	$567,109.71
90%	$596,546.41
100%	$739,904.69

Forecast: NPV Alternative IIIb Procurement Cost **Alternative IIIb LCC Model**

Summary:

Display Range is from $125,000.00 to $375,000.00
Entire Range is from $122,257.87 to $424,405.18
After 2,000 Trials, the Std. Error of the Mean is $1,016.47



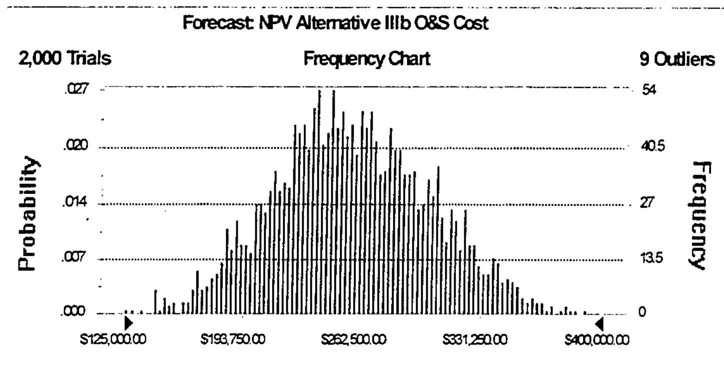
Percentiles:

Percentile	Value
0%	$122,257.87
10%	$200,388.78
20%	$218,134.64
30%	$232,388.94
40%	$245,838.39
50%	$257,024.61
60%	$269,074.58
70%	$281,598.34
80%	$297,077.08
90%	$314,408.08
100%	$424,405.18

Forecast: NPV Alternative IIIb O&S Cost **Alternative IIIb LCC Model**

Summary:

Display Range is from $125,000.00 to $400,000.00
Entire Range is from $100,580.20 to $422,085.16
After 2,000 Trials, the Std. Error of the Mean is $1,026.11



Percentiles:

Percentile	Value
0%	$100,580.20
10%	$199,122.63
20%	$217,554.85
30%	$231,056.36
40%	$243,181.10
50%	$254,448.50
60%	$266,605.31
70%	$280,592.53
80%	$296,961.70
90%	$317,147.95
100%	$422,085.16

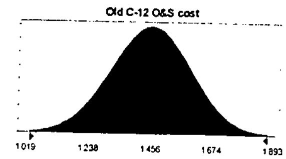
Assumptions

Assumption: Old C-12 O&S cost

Cell: B3

Normal distribution with parameters:

Mean	1.456
Standard Dev.	0.146



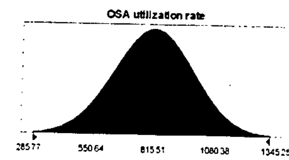
Selected range is from -Infinity to +Infinity
Mean value in simulation was 1.457

Assumption: OSA utilization rate

Cell: B5

Normal distribution with parameters:

Mean	815.51
Standard Dev.	176.58



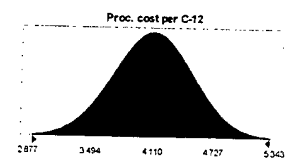
Selected range is from -Infinity to +Infinity
Mean value in simulation was 817.52

Assumption: Proc. cost per C-12

Cell: B9

Normal distribution with parameters:

Mean	4,110
Standard Dev.	411



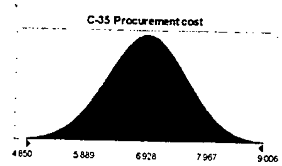
Selected range is from -Infinity to +Infinity
Mean value in simulation was 4,101

Assumption: C-35 Procurement cost

Cell: B26

Normal distribution with parameters:

Mean	6,928
Standard Dev.	693



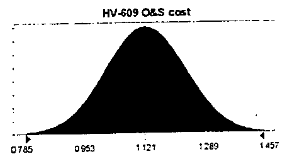
Selected range is from -Infinity to +Infinity
Mean value in simulation was 6,906

Assumption: HV-609 O&S cost

Cell: F30

Normal distribution with parameters:

Mean	1.121
Standard Dev.	0.112



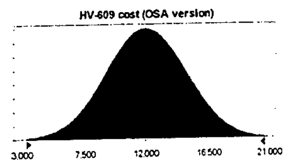
Selected range is from -Infinity to +Infinity
Mean value in simulation was 1.123

Assumption: HV-609 cost (OSA version)

Cell: F34

Normal distribution with parameters:

Mean	12,000
Standard Dev.	3,000



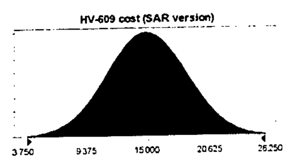
Selected range is from -Infinity to +Infinity
Mean value in simulation was 12,049

Assumption: HV-609 cost (SAR version)

Cell: F37

Normal distribution with parameters:

Mean	15,000
Standard Dev.	3,750



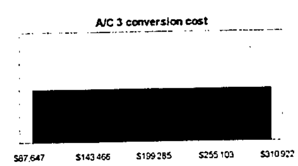
Selected range is from -Infinity to +Infinity
Mean value in simulation was 15,044

Assumption: A/C 3 conversion cost

Cell: F13

Uniform distribution with parameters:

Minimum	$87,647
Maximum	$310,922

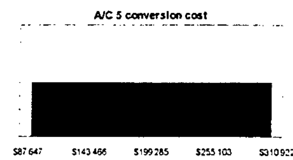


Mean value in simulation was $198,654

Assumption: A/C 5 conversion cost **Cell: F14**

Uniform distribution with parameters:

Minimum	$87,647
Maximum	$310,922

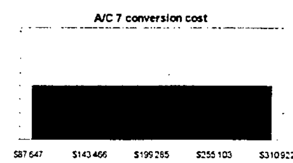


Mean value in simulation was $198,344

Assumption: A/C 7 conversion cost **Cell: F15**

Uniform distribution with parameters:

Minimum	$87,647
Maximum	$310,922

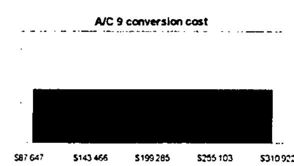


Mean value in simulation was $197,893

Assumption: A/C 9 conversion cost **Cell: F16**

Uniform distribution with parameters:

Minimum	$87,647
Maximum	$310,922

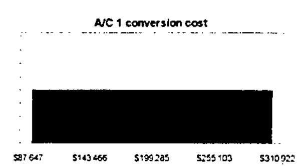


Mean value in simulation was $198,954

Assumption: A/C 1 conversion cost **Cell: F12**

Uniform distribution with parameters:

Minimum	$87,647
Maximum	$310,922

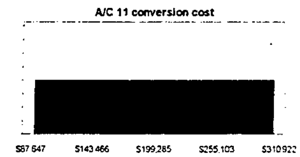


Mean value in simulation was $202,731

Assumption: A/C 11 conversion cost **Cell: F17**

Uniform distribution with parameters:

Minimum	$87,647
Maximum	$310,922

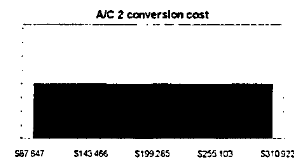


Mean value in simulation was $196,191

Assumption: A/C 2 conversion cost **Cell: G12**

Uniform distribution with parameters:

Minimum	$87,647
Maximum	$310,922

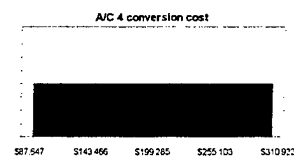


Mean value in simulation was $199,245

Assumption: A/C 4 conversion cost **Cell: G13**

Uniform distribution with parameters:

Minimum	$87,647
Maximum	$310,922

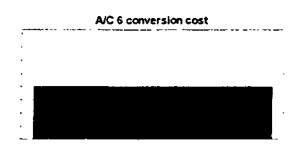


Mean value in simulation was $198,752

Assumption: A/C 6 conversion cost **Cell: G14**

Uniform distribution with parameters:

Minimum	$87,647
Maximum	$310,922

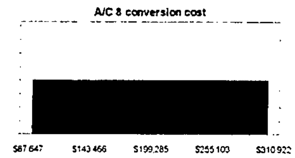


Mean value in simulation was $196,274

Assumption: A/C 8 conversion cost **Cell: G15**

Uniform distribution with parameters:

Minimum	$87,647
Maximum	$310,922

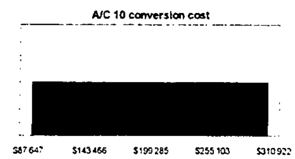


Mean value in simulation was $198,476

Assumption: A/C 10 conversion cost **Cell: G16**

Uniform distribution with parameters:

Minimum	$87,647
Maximum	$310,922

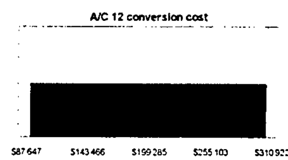


Mean value in simulation was $200,524

Assumption: A/C 12 conversion cost **Cell: G17**

Uniform distribution with parameters:

Minimum	$87,647
Maximum	$310,922

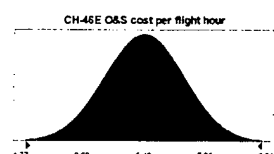


Mean value in simulation was $199,709

Assumption: CH-46E O&S cost per flight hour **Cell: J4**

Normal distribution with parameters:

Mean	5.49
Standard Dev.	1.24



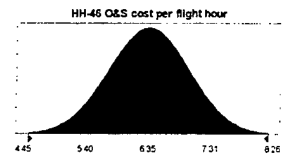
Selected range is from -Infinity to +Infinity
Mean value in simulation was 5.49

Assumption: HH-46 O&S cost per flight hour **Cell: J8**

Normal distribution with parameters:

Mean	6.35
Standard Dev.	0.64

Selected range is from -Infinity to +Infinity
Mean value in simulation was 6.36

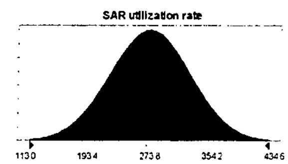


Assumption: SAR utilization rate **Cell: J13**

Normal distribution with parameters:

Mean	273.8
Standard Dev.	53.6

Selected range is from -Infinity to +Infinity
Mean value in simulation was 272.9

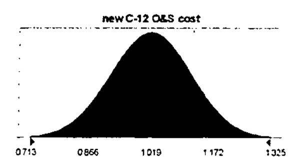


Assumption: new C-12 O&S cost **Cell: B7**

Normal distribution with parameters:

Mean	1.019
Standard Dev.	0.102

Selected range is from -Infinity to +Infinity
Mean value in simulation was 1.018

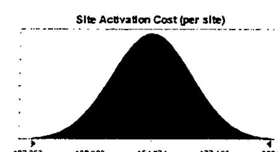


Assumption: Site Activation Cost (per site) **Cell: B42**

Normal distribution with parameters:

Mean	154,074
Standard Dev.	15,407

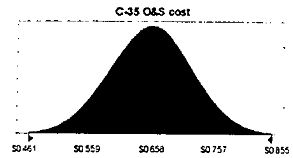
Selected range is from -Infinity to +Infinity
Mean value in simulation was 153,626



Assumption: C-35 O&S cost **Cell: B22**

Normal distribution with parameters:

Mean	$0.658
Standard Dev.	$0.066

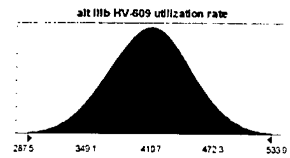


Selected range is from -Infinity to +Infinity
Mean value in simulation was $0.655

Assumption: alt IIIb HV-609 utilization rate **Cell: J17**

Normal distribution with parameters:

Mean	410.7
Standard Dev.	41.1



Selected range is from -Infinity to +Infinity
Mean value in simulation was 410.4

End of Assumptions

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APPENDIX D. CH-46E CONVERSION COST ESTIMATE

CH-46E Conversion Cost Estimate
provided by the CH-46E program office
all costs in $FY00

system	components	unit cost	labor	kit
Search light			$4,000	$2,000
	Light	$6,240		
	Junction box	$2,275		
	control	$1,115		
	gimble	$3,580		
		$13,210		
Loud Hailer				
	controller & speakers	$11,079	$4,000	$2,000
Commercial V/UHF Radio				
	radio & ant.	$25,000	$4,000	$2,000
Doppler				
	unit	$125,000	$4,000	$2,000
Doppler controller				
	control box	$30,000	$4,000	$2,000
		$204,289	$20,000	$10,000
NRE	total=$200,000 based on 10 conversions	$20,000 per aircraft		

min cost per plane excluding paint:	$50,000
max cost per plane excluding paint:	$254,289

SAR paint scheme

overpaint labor & material	$41,635
strip and paint labor & material	$70,780

absolute min cost including paint	$91,635
absolute max cost including paint	$325,069

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LIST OF REFERENCES

1. Department of Defense Directive 4500.43, Operational Support Airlift, 28 October 1996.
2. Clark, Major Kenneth, USMC, Chief of Naval Operations Transportation/Utility Requirements Officer (N-880G1), telephone interview with the author, 26 December 1999.
3. Joint Staff, Wartime Requirements for Operational Support Airlift (OSA), October 1995.
4. Joint Publication 3-50, National Search and Rescue Manual, Volume I: National Search and Rescue System, 1 February 1991.
5. Clayton, Major Christopher, USMC, APP-41, Headquarters, United States Marine Corps, electronic correspondence with the author, 29 September 1999.
6. Marine Transportation Squadron One (VMR-1), Squadron Order P3710.1G, "Standard Operating Procedures for Flight Operations", 4 January 2000.
7. Hinebaugh, Jim, PMA 207 Assistant Deputy Program Manager C-12, telephone interview with the author, 18 August 1999.
8. Federal Association of Scientists, "C-12 Huron" [Online] Available http://www.fas.org/man/dod-101/sys/ac/c-12.htm, 1999.
9. Hinebaugh, Jim, PMA 207 Assistant Deputy Program Manager C-12, telephone interview with the author, 28 October 1999.
10. Federal Association of Scientists, "UC-35A" [Online] Available http://www.fas.org/man/dod-101/sys/ac/uc-35.htm, 1999.
11. Clubb, Lieutenant Timothy, USMC, APW-53, Headquarters, United States Marine Corps, electronic correspondence with the author, 6 July 1999.
12. Boeing Rotorcraft, "CH-46E Seaknight" [Online] Available http://www.boeing.com/rotorcraft/military/ch46e/images/ch46e06.htm, 2000.

13. Schneider, J. J., "Rotary Wing V/STOL: Development of the Tiltrotor", The Age of the Helicopter: Vertical Flight, Smithsonian Institution Press, Washington, D.C., 1984.

14. Prouty, R. W., "From XV-1 to JVX – A Chronicle of the Coveted Convertiplane", Rotor & Wing International, Vol. 18, February 1984.

15. "V-22...The Future Is Here!", Bell-Boeing Publication, 1997.

16. Maher, Guy, "A CTR Look at the XV-15", Rotor and Wing International, Vol. 30, November 1996.

17. National Aeronautics and Space Administration, Ames Research Center Imaging Library Server, "XV-3" [Online] Available http://ji20951.arc.nasa.gov:80/Images/Aeronautics/AC-26438.html, 1999.

18. National Aeronautics and Space Administration, Dryden Flight Research Center, "XV-15" [Online] Available http://www.dfrc.nasa.gov/gallery/photo/XV-15/index.html, 1999.

19. Boeing Rotorcraft, "V-22 Osprey" [Online] Available http://www.boeing.com/rotorcraft/military/v22 /images/ v2201.htm, 1999.

20. V-22 Transition Task Force [Online] Available http://v22.sra.com/docs, 1999

21. Bell Helicopter Textron Inc., "BA-609" [Online] Available http://www.bhti.com/products/tiltRotor/609/index.html

22. Naval Aviation Training and Operating Procedures Standardization (NATOPS), General Flight and Operating Instructions, OPNAV 3710.7R, 15 January 1997.

23. Minnesota Department of Natural Resources, [Online] Available http://www.dnr.state.mn.us/information and education/water safety/bg-tips.html, 1999

24. Naval Center for Cost Analysis, [Online] Available http://www.ncca.navy.mil, 1999

25. Aircraftbuyer.com, Aviation Week's A/C Flyer, [Online] Available http://www.aircraftbuyer.com, 2000.

26. Office of Management and Budget, OMB Circular A-94, "Discount Rates to be Used in Evaluating Time-Distributed Costs and Benefits," 29 October 1992

27. Riso, Major Brian, USMC, ADPMSE CH-46E, NAVAIRSYSCOM, electronic correspondence with the author, 23 February 2000.

28. Welsh, Jana, Manager, U.S. Coast Guard Requirements, Bell Helicopter Textron Inc., electronic correspondence with the author, 27 September 1999.

29. Yen, T. Shen, Assistant Deputy Program Manager, C-35, PMA 207, interview with the author, 25 January 2000.

30. Bower, Ron, "Your First Helicopter", Rotor & Wing International, Vol. 33, October 1999.

31. Table of Manpower Requirements (Trooplist), Marine Corps Total Force Structure Division, Marine Corps Combat Development Command, Quantico VA, 1 February 1999.

32. "BA-609 Tiltrotor, An Aircraft for the Next Millennium" Bell/Agusta Aerospace Company Brochure, 1999.

33. The Cessna Aircraft Company, "Cessna Citation Encore", [Online] Available http://www.cessna.textron.com/encore, 1999

34. Raytheon Aerospace Company, "KingAir B200", [Online] Available http://www.rtn.com/rac/kab200/specifications.html, 1999.

35. Naval Aviation Training and Operating Procedures Standardization (NATOPS) Flight Manual, Navy Model CH-46E, 15 July 1996

36. "Logical Decisions for Windows" Student Version 3.015, Logical Decisions, Golden, CO, 1993.

37. "Crystal Ball" Version 4.0, Decisioneering, Denver, CO, March 1997.

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