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MONTEREY, CALIFORNIA

MBA PROFESSIONAL REPORT

**An Analysis of Retaining or Replacing Air Force Command and
Control Aircraft**

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 December 2007**

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**AN ANALYSIS OF RETAINING OR REPLACING AIR FORCE
COMMAND AND CONTROL AIRCRAFT**

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Submitted in partial fulfillment of the requirements for the degree of

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from the

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AN ANALYSIS OF RETAINING OR REPLACING AIR FORCE COMMAND AND CONTROL AIRCRAFT

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I. INTRODUCTION

Air Force strategic command and control aircraft are aging with the newest aircraft being the E-8 Joint Surveillance Target Attack Radar System (JSTARS) that became operational in 1996 [1]. The Air Force has not purchased additional command and control aircraft since the JSTARS aircraft, but aircraft have been retired, enabling other services to perform missions once delegated as Air Force specific. In a joint environment, this may be more economical for the Department of Defense (DoD); however, this research attempts to uncover what challenges face the Air Force with an aging strategic command and control aircraft fleet and how to continue accomplishing these critical missions.

The Air Force, similar to other services, is currently facing a budget crisis. Budget cuts are forcing decreases in personnel and cuts in the number of aircraft the Air Force desires for operational levels. Much attention has been drawn to the need for new fighter and tanker aircraft; however, the Air Force is also facing difficulties with its command and control aircraft. These aircraft at times receive less priority and risk being cut to allow money for other programs. The aircraft were heavily relied on during and after the Cold War, and the aircraft have important missions that may prove essential in the unstable world we currently face.

The Air Force is not the only service facing aging aircraft challenges. The Navy has decided to update its critical P-3 aircraft to meet future mission requirements [2]. The aircraft's primary mission is to perform Anti-Submarine Warfare (ASW) and Anti-Surface Warfare (ASuW). The aircraft is propeller driven and has proven to be a valuable asset over time. The Navy has chosen to upgrade the aircraft to a newer Boeing 737 platform. The 737 incorporates more fuel efficient jet turbofan engines and also increases the capacity of the aircraft. The increased capacity can allow for more communication or mission equipment to be installed and increased fuel storage for a longer flight range. The 737 is the backbone of many commercial airlines, so the availability of parts and maintenance centers will be readily available wherever the aircraft may be utilized.

The United States' military services are not the only ones updating their fleets. The Air Force could look at foreign militaries to compare actions taken to determine if foreign military decisions could be beneficial to domestic forces. Japan is one country that has decided to upgrade its command and control aircraft. Japan has decided to utilize the Boeing 767 as the platform for Airborne Warning and Control System (AWACS) aircraft. The aircraft offers increased capacity as well as increased fuel efficiency to allow it to be an advantage over the existing 707 platform the Air Force uses for its AWACS aircraft.

There is a tendency to focus on short term "hot" circumstances instead of problems that may arise in the future. While the Air Force is continuing to perform its command and control missions, the aircraft are aging and have received numerous modifications to keep them up to date with a rapidly changing environment. If the aircraft are not given a priority for ongoing modifications or for new aircraft procurement, they may eventually be unable to accomplish their primary missions.

A. SUBJECT OF MBA PROJECT

The project examines whether the Air Force should retain or replace its command and control aircraft to continue accomplishing command and control missions. Current budget cuts have caused the Air Force to decrease procurement of new command and control aircraft. Many dollars are being obligated to the F-22 and F-35 aircraft, and money is being reserved for the next generation tanker aircraft. With all of the cuts and planning for fighter and tanker aircraft, the command and control aircraft have faced difficulties. The Air Force has turned an Air Force command post mission over to the Navy, and the Air Force must formulate a future plan and decide how to accomplish command and control missions in the future. An analysis will be conducted to determine a course of action to take given the current environment and situation. With budget cuts continuing to threaten future programs, the Air Force must ensure its priorities are aligned to counter potential world threats. Specifically, the following areas will be addressed:

- Identify current command and control aircraft
- Identify potential replacement aircraft for command and control missions
- Define challenges facing the Air Force's recapitalization efforts
- Present conclusions, recommendations, and additional areas for further research

The research is organized in the ensuing manner: Chapter I provides an introduction to the research project by identifying the subject of the project and background. The scope and methodology are also outlined in Chapter I. Chapter II consists of literature review and introduces the reader to the Air Force's recapitalization efforts for its command and control aircraft. Current and potential replacement aircraft are identified and cost / performance specifications are listed. Chapter III is the major analysis section of the project and also states assumptions made for the purpose of the project. Chapter IV informs the reader of challenges facing the Air Force's recapitalization efforts. In particular, the costs, schedule, and performances of the aircraft are identified. This section also describes funding priorities and production lead times as well as facilities and support equipment. Chapter V outlines the conclusion and recommendation from the research and identifies additional areas for further research.

B. MISSION DESCRIPTIONS

1. Command and Control Mission Development

The United States Air Force played a vital role during the Cold War. The force was heavily relied on to fill urgent, vital roles ensuring our nation was prepared for any aggressive act by the Soviet Union. The Cold War really heated up once the Soviets learned the United States had created an atomic bomb and used it against Japan. Alone, this could potentially be the single act that started the arms race between the United States and the Soviet Union. In the years that ensued, the United States gradually became more disturbed with the Soviets' increased progress in their development of Intercontinental Ballistic Missile (ICBM) technology. Defense planners were aware that if the Soviet Union launched an operational ICBM at United States interests (military

installations and airfields), Strategic Air Command (SAC) would have fewer than 15 minutes to launch a bomber force for a counter attack [3].

In October of 1957, the Soviet Union put the world on notice with its technological advances when they used missiles to launch the first orbiting satellite, Sputnik I, into space. One month later, the Soviets launched Sputnik II with a dog named Laika. With the race for space ignited, the United States defense planners concluded that the only means of ensuring a retaliatory strike should the Soviets strike first was to place bombers and tankers on fast response alert status [4]. One third of the Air Force's bomber fleet was placed on a continuous 15-minute alert status, and in 1960, the nation's nuclear submarine arsenal joined the continuous alert status by remaining submerged at times up to 60 days. These circumstances contributed to the formation of an airborne command post. During this time, the Air Force constantly maintained a state of readiness and ensured strategic forces were equipped, trained, and available at a moment's notice [4].

The American public was aware of various nuclear threats they faced during the Cold War. Many publications were produced, and the news information was carried throughout the country. One article of particular concern was the September 15, 1961 issue of the Life Magazine. President John F. Kennedy wrote a letter that was published to the American public [5].

The letter was published three months after President Kennedy's meeting with Nikita Khrushchev, the Soviet leader. The title on the cover of the magazine was, "How You Can Survive Fallout". Kennedy's message to the American public was "there is much you can do to protect yourself against the threat of nuclear fallout." People were instructed on how to adequately prepare for and survive a nuclear attack [5].

The government had conducted surveys of buildings that could be used as fallout shelters, and they instructed that food and water be distributed to key distribution centers for storage and use after a nuclear attack. The government also developed warning systems for people to be aware of danger and informed to take immediate shelter. One year after the message was published, President Kennedy and the world watched as

America and the Soviet Union faced off in the Cuban Missile Crisis. This event almost brought the world to a full scale nuclear war [5].

On the military side, bombers and other electronic aircraft were being produced and deployed to various locations to support military operations. The improvements being made in the bomber and missile assets would be ineffective if the command and control structure were left damaged or ineffective. This dilemma led the Air Force to perform necessary improvements in the communication structure. One necessary improvement was the use of a 'Short Order' using a High Frequency Single Side-Band radio link ensuring positive control of bomber aircraft. The aircraft were instructed not to proceed beyond certain points without authenticated orders. The airborne command posts were enhanced, and the concept of having redundant command forces in the air was heavily utilized and is still used today. Eventually, the constant commitment of command facilities and aircraft led to the forming of SAC now known as United States Strategic Command (USSTRATCOM) [6].

SAC was developed to control the United States' strategic nuclear weapon systems. The command initially controlled B-52 Stratofortress and GB-111 aircraft in an alert status ready to takeoff with minimal notice. They also were responsible for missiles and their crews that performed underground duties. Even though SAC maintained a devastating amount of weapons, their primary purpose was to deter other countries from attacking the United States because of the amount of retaliation strikes that would be counter-launched.

SAC formally began on March 21, 1946 as a combatant command of the United States Army Air Force, and General George C. Kenney was assigned as the Commanding General. SAC was noticed by others as a command that would be able to project its power globally even during its early years. In the beginning, the command had few transport and intelligence aircraft [6].

In 1948, SAC began to increase with new organizations, equipment and missions. Lt. Gen Curtis E. LeMay was appointed SAC Commander on October 19, 1948. He

would become the father of SAC and moved the Headquarters to Offutt Air Force Base in Omaha, Nebraska. Gen LeMay was known as a tough person that weeded out weaker subordinate officers.

SAC's presence was increased with additional units being established, the introduction of forward basing, in-flight refueling, and the introduction of jet powered aircraft. SAC's major role was to deter a Soviet attack. Bombers, tankers, and certain airlift aircraft were used to accomplish SAC's objectives. SAC also had certain missile sites at its command to launch ICBMs armed with nuclear warheads.

Missiles played a critical part in SAC's success. The most important missile was the Minuteman, and it could be based at a permanent silo or placed on mobile equipment to allow movement around the country. The Minuteman missiles were eventually updated to Peacekeeper missiles that were intended to be used against protected targets such as command structures and missile silos. The Peacekeeper could fly over 700,000 feet at a range of 7,000 nautical miles. The Titan II was another missile that was important to SAC. The missile weighed 327,000lbs and was the largest ICBM in SAC's arsenal. They were based in Arizona, Arkansas, and Kansas. The missile was complex and required additional experienced personnel to operate and maintain it [6].

While the Air Force was modernizing and enlarging bomber fleets to carry out strategic missions, the bases they were stationed at were becoming overwhelmed. Large concentrations of aircraft at single locations created an easy target for the Soviets. In the event of an attack, the probability of getting a large amount of the aircraft in the air would be minimal, so SAC decided to disperse their aircraft to different bases. The dispersal would allow more aircraft to get airborne if the country was attacked by an ICBM. SAC also placed aircraft on ground alert to minimize the time required for the crews to get airborne. Bombers and tankers maintained ground alert status; however airborne alert status was also utilized during conflicts to keep aircraft ready for any possible engagements.

SAC was deactivated on June 1, 1992, and USSTRATCOM was activated. The world had changed from the former Soviet Union threat to a world with multiple threats around the globe. The transition also marked a change of certain missions from being Air

Force specific to being joint in nature. The EC-135 Looking Glass mission was an example of a mission that continued from SAC to USSTRATCOM and evolved as various threats changed [7].

The EC-135 Looking Glass aircraft was a specially configured aircraft that allowed the military to command the nuclear triad if the ground command and control facilities were not able to function. There was always one aircraft in the air from 1961 to 1990, ensuring an attack by the Soviet Union would be countered with proper force. The EC-135 was built on a Boeing 707 platform with communication upgrades that allowed the aircraft to communicate with bombers as well as ground missile forces [8].

The EC-135 performed a strategic mission by ensuring the military's ability to command, control, and communicate with nuclear forces during a nuclear attack. The name "Looking Glass" was given to certain aircraft missions due to the aircraft being "mirrored" to ground command and control facilities [8]. The aircraft was an essential backup to the ground based facility and could perform the same mission as the crew on the ground. Figure 1 is a picture of an EC-135 aircraft.



Figure 1. EC-135 "Looking Glass"
From <http://www.fas.org/nuke/guide/usa/c3i/ec-135.htm>

When airborne, the EC-135 aircraft was under the command of a flag officer from the Air Force or the Navy, and it supported the National Command Authority as well as

the Commander in Chief of USSTRATCOM [9]. The officers were from a variety of commands to include United States Strategic Command, United States Transportation Command, Air Force Air Combat Command, Air Force Space Command, Navy's Commander, Submarine Group NINE, and Pacific and Commander, Submarine Group TEN. Battlestaff members were from all military branches and formed operational teams. The team chief ensured training was conducted and ensured the team was a cohesive group. The communications officer ensured the aircraft's communications operated properly and that messages were properly routed from the battlestaff. The airborne launch officer led the missile launch team and controlled the airborne launch control system. This crucial system enabled the Looking Glass aircraft to transmit the authentication codes to launch missiles in the event the ground control centers were damaged. The emergency action non-commissioned officer was responsible for formatting the emergency action messages that discharged the war plans. The standard flight crew included two pilots, navigator, airborne refueling operator, and communications operators/technicians. The aircraft and crew were based at Offutt Air Force Base, Nebraska until they were retired in October 1998. At that time, the Navy E-6B began performing the Looking Glass mission [8]. Ultimately, the fate of the EC-135 would rest in budget realignments and the capabilities of a similar program being administered by the United States Navy. Table 1 displays the EC-135 aircraft specifications.

EC-135 Aircraft Specifications	
Primary Function	Survivable USSTRATCOM Command & Control System for Nuclear Forces
Contractor	Boeing Military Airplanes Division
Crew	28
Unit Cost	N/A
Powerplant	Four Pratt & Whitney TF33-PW-102 turbofan engines at 16,000 pounds each
Length	128 feet
Wingspan	131 feet
Height	43 feet
Maximum Takeoff Weight	300,000 pounds
Speed	500+ mph (Mach 0.66)
Ceiling	Above 45,000 feet
Endurance	Approximately 6,000 miles

Table 1. EC-135 Specifications

From http://www.globalaircraft.org/planes/ec-135_looking_glass.pl

The EC-135 “Looking Glass” mission was a predecessor to current and future command and control aircraft missions. Current command and control missions that are identified in the project include the National Airborne Operations Center, Airborne Warning and Control System, and the Joint Surveillance Attack Radar System missions. The following section describes the missions, and the aircraft will be introduced in Chapter II.

a. National Airborne Operations Center Mission

The National Airborne Operations Center (NAOC) mission is valuable in national emergencies and peacetime operations. In the event the ground facilities can no longer command the military forces or if another national emergency arises, the NAOC mission ensures the National Command Authority (President, Secretary of Defense, and Joint Chiefs of Staff) has a command, control, and communication platform to continue directing military and civilian personnel. During peacetime, NAOC supports the Federal

Emergency Management Agency (FEMA) when areas have been affected by natural disasters such as hurricanes, earthquakes, and any other disaster that could inhibit communication throughout the United States [10].

b. Airborne Warning and Control System Mission

The Airborne Warning and Control System (AWACS) Mission provides commanders with “all-weather surveillance, command, control, and communications [11]” to ensure effective decisions can be made during contingency and peacetime operations. The mission is accomplished abroad and over the continental United States. The mission enables commanders to see aircraft similar to an air traffic controller on the ground.

c. Joint Surveillance Attack Radar System Mission

The Joint Surveillance Attack Radar System Mission “provides theater ground and air commanders with ground surveillance to support attack operations and targeting that contributes to the delay, disruption, and destruction of enemy forces [1]. The mission is critical to ensure ground commanders are equipped with the latest information concerning ground adversarial forces during contingency operations.

2. Importance of Maintaining Command and Control Capabilities

The fall of the Iron Curtain not only brought an end to the Cold War, but it ushered in a new era filled with brazen and independent states that are more willing to push the envelope when it comes to testing the political prowess of superpower countries. The bipolar relationship that existed between the United States and the Soviet Union was replaced by multilateral relationships between the United States and a multitude of independent nation states. In a sense, the United States has more countries to maintain foreign relations with [12].

The Cold War era ushered an institutionalized fear of nuclear power. As the Cold War came to a close, the political environment took on new dynamics with the introduction of new country states. The fear of nuclear war was replaced by nuclear proliferation not only amongst rogue nations, but also by terrorist organizations [13]. The balance of power that existed between the superpowers was transformed into the haves and the have-nots. Almost overnight, there were small nations who either obtained nuclear power or were already in pursuit of Weapons of Mass Destruction (WMD) technology. Most aggressors came from dictators or terrorist organizations. Countries without nuclear armament felt it necessary to pursue the technology in order to defend themselves or simply validate their existence in the world pecking order [13].

The current world platform involves countries like China, India, North Korea, and Iran becoming major players in the relentless pursuit to position themselves as influential mediums in world politics. Whether it is to gain attention or other ulterior motives, countries are utilizing the threat to produce nuclear weapons as a bargaining tool to showcase their political legitimacy. For some, the threat does not come from the fact that one country could possess nuclear capabilities, but it stems from the possibility that countries could arm themselves against a threat posed by neighboring countries that possess nuclear capabilities. From this example, it is understandable how the containment of nuclear proliferation can be a problem for countries like the United States in their bid to discourage other nations from pursuing the nuclear technology [14].

Today there are eight countries that are known to have nuclear weapons. Under the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), only five countries are recognized as having the special rights and privileges covered under international law required to maintain nuclear weapons. According to the size of their nuclear cache, they are: Russia, United States, China, France, and the United Kingdom. These nations obtained their caches during the period following World War II [14].

In 1998, both Pakistan and India communicated to the world that they were in possession of nuclear technology by detonating nuclear devices. Although both countries communicated their intentions of using nuclear weapons, neither country has deployed any to date; however, both nations do possess the technology and capability to arm

aircraft and missiles with nuclear devices. In addition to India and Pakistan, it is speculated that Israel is in possession of nuclear weapons as well, but they have neither confirmed nor denied the allegations. Israel, India, and Pakistan are not members of the NPT [14].

Although only eight countries are known to be in possession of nuclear weapons, a greater number of countries are actively seeking the technology. In January 2001, the Office of the Secretary of Defense issued a report titled “Proliferation: Threat and Response”. The report stated at least 25 countries either possess or are actively in the process of obtaining nuclear, biological and chemical (NBC) technology to develop WMD.

The report singled out North Korea, Iran, and Libya as countries pursuing WMD. According to the report, North Korea had chemical and biological technology and was engaged in fabricating and selling long-range missiles, and they may have already redirected missile material for use in nuclear weapons. With foreign intervention, Iran, which already had a chemical arsenal, was able to buy and develop longer-range missiles while researching nuclear and biological technology. In addition, Libya was reported to be in possession of chemical assets and was attempting to buy long-range missiles [15].

At the time, the incumbent Secretary of Defense voiced concerns regarding the security threat posed by nuclear proliferation. The Secretary noted that although it is impossible to halt proliferation, slowing it is important and achievable. The chances of such capability finding its way to individuals or members of fanatical terrorist groups are significantly greater now than during the Cold War. It is no secret that Osama Bin Laden has trained his Al Qaeda followers to use toxic chemicals, and further intelligence has suggested that terrorist groups are seeking other forms of WMD including the procurement of a dirty bomb [15].

With the turn of the 21st century, the United States finds itself in a quandary as the lone superpower. As the war in Iraq has proven, enemies are testing the United States’ supremacy of conventional warfare with unconventional and asymmetric methods. After realizing the effect of nuclear proliferation on American policy, the

importance for the world's premier Air, Space, and Cyberspace Force to preserve and maintain a viable mobile command and control asset is understandable [15].

C. SCOPE AND METHODOLOGY

The project focuses on two options: 1) Retain existing command and control aircraft; or 2) Replace existing command and control aircraft with one common platform. the project does not examine whether some existing aircraft should be retained and others replaced, or whether a mixture of new aircraft can be utilized to accomplish command and control missions. In the introductory chapter, the subject of the MBA project and mission descriptions was described. The research methodology is stated below.

Research was conducted from official government sources including the Air Force and Navy websites and literature reviews utilizing the Naval Postgraduate School's library resources. Some information was conducted by general research in commercial resources and compared to official sources to ensure a mixture of information was presented. Some sources utilized included news agencies and magazines that included articles over political figures and/or military missions. The researchers compared unit costs of aircraft and modifications of aircraft to determine the best approach for command and control aircraft. In particular, a Government Accountability Office report detailing RC-135 engine improvements proved extremely helpful to determine estimated cost and results from any re-engining effort made on existing aircraft. The researchers compared existing aircraft with newer aircraft of various sizes to determine what option would prove most beneficial to the Air Force.

The research also attempted to gain additional understanding of how other services are upgrading their command and control aircraft to determine if their methods would be feasible for the Air Force to utilize. The Navy is facing a similar situation with their aging P-3 aircraft, so their actions were addressed as well as Japan's decision to procure 767 AWACS aircraft. Research attempted to discover if the Air Force would be able to reduce initial research and development costs if they followed similar decisions these militaries chose for their fleet.

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II. LITERATURE REVIEW

A. INTRODUCTION OF AIR FORCE RECAPITALIZATION EFFORTS

The Air Force is at a crossroads and is attempting to re-balance its personnel in order to provide funding for modernizing aircraft. Currently, fighter and tanker aircraft are receiving attention and having funds added to purchase new aircraft. The command and control aircraft have been performing at an increased operations tempo similar to tanker and cargo aircraft, but they have not received the attention needed to ensure modernizations or new aircraft are funded to keep their capability for the future.

B. CURRENT COMMAND AND CONTROL AIRCRAFT REVIEW

1. E-4B Aircraft – Cost / Performance Specifications

The initial cost of each E-4B was \$125M, and this amount only included the Boeing 747-200 aircraft. The aircraft were then shipped to E-Systems for their communication upgrades. The modification cost millions of dollars, and it ran the total cost of one E-4B to approximately \$258M [16]. The equipment on the E-4B takes abuse during takeoffs, landings, and during flight from power surges that cause the equipment to malfunction and require replacement more often than if the equipment was stationary on the ground.

The E-4B has undergone numerous modifications since its inception in the 1970s. Estimates at the time of the production of the first E-4B placed the developmental cost at nearly \$1B. According to Jane's, on February 28, 1973, Boeing was awarded a then-year \$59M contract to provide two Boeing 747-200 aircraft to be used as National Emergency Airborne Command Post (NEACP) aircraft. The first two aircraft were 73-1676 and 73-

1677. Later in the same year, Boeing received another contract to supply two additional 747-200 aircraft. The aircraft were 74-0787 and 75-0125 and had a collective then-year contract of \$66.7M [10].

The aircraft received initial command, control, and communications equipment from EC-135J aircraft that were de-modified by E-Systems. The initial modification was designated Phase 1A-2 part of the program and also involved: modifying the aircraft for the specific role it would perform; installing the VLF/LF trailing wire antenna; modifying the electrical power, hydraulic and air conditioning systems for the mission; installing workstation consoles, seats, bunks, stairways, and emergency equipment; and obtaining a Federal Aviation Administration (FAA) certification for the aircraft [10].

In 1974, E-Systems continued de-modifying EC-135Js for equipment transfer to 73-1677 and 74-0787. They also began negotiations for modifying 75-0125 with the Phase 1B-2 modification. Aircraft 75-0125 is the only E-4 that actually began its service as an E-4B. The three additional aircraft began their missions as E-4A aircraft and later received the modifications to upgrade them to an E-4B. The first E-4 upgraded to the E-4B designation was delivered on July 15, 1983 [10].

Despite ongoing modifications, new technology is not always fielded immediately. At times when modifications have been performed, new equipment may become available that is better but not on the contract. On September 5, 2001, the Secretary of Defense, Donald Rumsfeld, told the military services to upgrade their air and ground strategic command and control equipment [10]. According to Lt Col Lauri De Garmo, E-4B system program manager at Tinker AFB, “The upgrades are needed to prevent interoperability problems with more modern ground elements [10].” The upgrades were named Block 5, and prototype equipment was scheduled for completion in 2003. Documents stated the E-4Bs would be Block 5 modified within 4 years of the initial modification start date, but later information explained some Block 5 modifications were re-designated as part of Modification Block 1 due to problems encountered [10].

The Modification Block 1 contract to modify the E-4Bs was awarded to Boeing on December 27, 2005, as a \$2B cap five year, indefinite delivery/indefinite quantity contract vehicle [17]. This modification includes an Audio Infrastructure Update (AIU)

that was previously identified for inclusion as Block 5A. It also encompasses the Global Air Traffic Management (GATM) II upgrade as well as the Senior Leaders Communication System (SLCS) modification. The AIU upgrade will allow proper audio distribution on internal systems and for the recording system. It highly modifies analog equipment from the 1960s era with digital technology that should eliminate major sustainment problems [10]. The modification also enhanced other communications components that were outdated or not functioning properly. One specific enhancement was the Data LAN Infrastructure. This modification was previously a part of Block 5B and will enhance the mission by allowing information for its primary mission to be received, stored, manipulated, distributed and viewed. Bandwidth the aircraft can utilize will also be increased internally and externally [10].

According to the 2006 Quadrennial Defense Review (QDR), the E-4B was scheduled to be retired at one per year beginning in fiscal year 2009 and ending in fiscal year 2012. The E-4Bs are late 1970s aircraft, and the technology they were initially developed with requires extensive modification. The program to upgrade it ran into several problems including exceeding the cost and schedule. The budget called for the rapid procurement of two C-32 aircraft to replace the four E-4Bs [18]. Although the Air Force was directed to retire all four E-4B aircraft beginning in 2009, the NAOC program is still scheduled to receive more than \$210M in modernization upgrades through the 2013 [18].

Despite the low-time on the airframe, the technology initially developed has not been friendly to the intense modifications placed on the aircraft. Systems such as the manual telephone switching unit were long replaced in the civilian sector but were still being used within the past 10 years on the E-4B. Many hours were spent troubleshooting this particular system and replacing the telephone circuit cards in its massive cabinet the size of a refrigerator. Newer telephone systems are the size of a small box and have a reliability rating far exceeding the older systems.

At the height of the Cold War, the plane was a highly valued asset. Today, it is still performing the alert, Senior Leader Support, and FEMA missions due to the dedicated men and women from Offutt Air Force Base, Nebraska. The C-32 aircraft

scheduled to replace the E-4B were to be equipped with “state of the art mission suites” to acquire the E-4B mission. The C-32 is a Boeing 757-200 aircraft, and the United States Air Force currently has four aircraft stationed at Andrews Air Force Base, Maryland [19]. Figure 2 displays an official photo of the C-32A aircraft.



Figure 2. Air Force C-32A

From <http://www.af.mil/shared/media/photodb/photos/051115-F-9999Z-001.jpg>

Currently, the United States’ military is engaged in two conflicts and attempting to retire a valuable asset during a time of war is the wrong decision. Congressman Tiahrt said it best when he mentioned “I am hopeful the Democrat leadership will understand the significance of this program, especially in a time of war” because “we have a state-of-the-art aircraft that can continue to serve a vital role for our nation’s defense for many years [20].” As a result of the DoD’s decision to retire all four aircraft in the E-4B fleet, United States Representative Todd Tiahrt from Kansas realized the implications involved with national security and also to hundreds of jobs in his home state. Immediately after learning of the Pentagon’s decision to retire the E-4B fleet, Congressman Tiahrt joined forces with the Pentagon and two fellow Congressmen, Senators Pat Roberts and Sam Brownback, both from Kansas. The trio began a campaign aimed at reversing the DoD’s

decision to retire the fleet. The trio centered support for reversing the decision to retire the fleet of aircraft on three main points: impact to American lives, degraded national security, and the already sunk cost of previous and on-going upgrades and maintenance to the fleet [20].

The first point emphasized that retiring the fleet of E-4Bs would negatively impact the economic status of hundreds of households by destroying jobs at Boeing's Wichita plant. In the end, a loss of hundreds of jobs would affect the lives of what could possibly amount to thousands of individuals. Congressman Tiahrt understood that in addition to putting Americans in the unemployment lines, the retirement had much more serious consequences that impact the entire nation.

The second argument emphasized the true scope of the situation. The congressmen made the argument that a forced retirement could seriously degrade national security because of the vital role each aircraft play in the nation's defense. Although there was no real way to measure the threat posed to national security if the planes were retired, it was a chance not worth taking. If and when the time comes, no one wants to defend the fact that a response to pre-emptive circumstances could not be accomplished because certain key assets were retired to save tax payer dollars [21].

The third argument focused on the fact half of the E-4B fleet had either received or was in the process of receiving some form of modification. For the past several years, the E-4B fleet has undergone various system upgrades and retiring the fleet would contribute to wasteful spending of tax dollars. In 2006 alone, the year in which the program's retirement was first announced, the program received close to \$14.3M for modernization initiatives and was slated to receive additional modernization funding in the out-years [22]. Retiring the E-4B fleet also meant the accelerated procurement of a replacement platform. With the current state of affairs, the procurement process could become costly and time consuming, especially in a time when funding is scarce and the cost of innovative technology seems to spiral out of control with each new initiative [21].

The fruits of the Senator Tiahrt's labor were realized with the signing of the President's fiscal year 2008 budget. The fiscal year 2008 budget confirmed that the President had authorized funding for the continuation of the E-4B fleet in the NAOC

program. With the reversal of DoD's decision, the Air Force had to establish new contracts with Boeing for maintenance of the E-4B fleet. The contracts called for the Air Force to contract with Boeing's Integrated Defense Systems' Wichita division to maintain routine maintenance work in addition to system upgrades for additional aircraft [21].

The fact that the program received a substantial amount of funding in fiscal year 2006 and is still on track to receive money in the out-years, is a major shift from the 2006 QDR which called for the retirement of all four aircraft by 2012. Although there this is no way to determine the future of the E-4B fleet, the Air Force's fiscal year 2008/2009 budget estimates reflect that the fleet is programmed to receive funding through fiscal year 2013. With the \$14.3M spent in fiscal year 2006, the fleet is scheduled to receive an additional \$23.9M from fiscal year 2007 and ending in fiscal year 2013. This, coincidentally, is one year after the fleet was scheduled for retirement [23]. Table 2 outlines the dollar break-down for fiscal year 2006 through fiscal year 2013.

Cost (\$M)	Fiscal Year 2006 Actual	Fiscal Year 2007 Estimate	Fiscal Year 2008 Estimate	Fiscal Year 2009 Estimate
Total Program Cost	14.3	0.3	19.5	4.1
	Fiscal Year 2010 Estimate	Fiscal Year 2011 Estimate	Fiscal Year 2012 Estimate	Fiscal Year 2013 Estimate
Total Program Cost	11.7	4.7	1.9	6.0

Table 2. E-4B Modification Funding

After <http://www.saffm.hq.af.mil/shared/media/document/AFD-070214-095.pdf>

With a mandate to keep flying the E-4Bs, the Air Force embarked on a plan to install Modification Block 1 on additional aircraft. This decision ensured the entire fleet will be modified by the fiscal year 2008/2009 timeframe. In conjunction with the modification due to be completed in fiscal year 2008/2009, additional upgrades will be

required through fiscal year 2013 to ensure the aircraft maintains a mission ready status. In response to the Department's directive, the Air Force decided to conduct a study on the future and the viability of the aircraft. The study is aimed at developing more cost-effective methods to maintain the fleet and simultaneously minimize mission and acquisition risk [23].

The E-4B NAOC is a militarized version of the Boeing 747-200. The aircraft can seat up to 114 aircrew members with a range of 12 hours un-refueled, and the aircraft can stay airborne for at least 72 hours with in-flight refueling. It was the first flight refueling airplane equipped with the advanced command, control and communication equipment. There are four E-4B aircraft stationed at Offutt Air Force Base, Nebraska, and they vary in ages from 1973 to 1975 models. The aircraft have communication capabilities from very low frequency to extremely high frequency [24].

The E-4B NAOC's primary mission is to serve as an airborne command center in the event of a national emergency or if ground command and control centers are destroyed [10]. The aircraft initially began fulfilling this role due to the NEACP program that was established in 1962. The program provided a method for providing secure communications in the event of a nuclear attack [10]. One aircraft has remained on alert 24 hours a day in case the United States is attacked by nuclear weapons. If attacked, the aircraft would pick up the President, Joint Chiefs of Staff, and other high ranking personnel to command the military if the ground command bunkers were destroyed [25]. The E-4B has additional missions to include supporting the Secretary of Defense, Secretary of State, and FEMA. The FEMA mission was given to the E-4B in August 1994, and the official name of the E-4B was changed from NEACP to NAOC [10]. The E-4B can assist FEMA by flying to a disaster location and fulfilling the role as a command center until normal operations can be restored. The E-4B allows FEMA to operate in a matter of hours compared to days without it [10].

The E-4B is a unique aircraft with a unique mission. The E-4B's main deck is comprised of six compartments: a National Command Authorities' staff area, briefing room, conference room, a central work area for the operations team, as well as communications and rest areas. The E-4B crew has been known to include a joint-

service operations team, security and maintenance personnel, a communications crew, an ACC flight crew, and a select group of augmentees [16].

The E-4B is protected from thermal radiation and pulses through an electromagnetic pulse (EMP) protection system. This system is designed to support the vast equipment on board the E-4B and protect it from nuclear blast pulses. The E-4B has other modifications that include nuclear and thermal effects shielding, an improved technical control facility, and an upgraded air conditioning system to cool the electrical equipment [10]. The platform's cabin air management system was also modified to block radiation exposure. The E-4B also has a sophisticated satellite communications system enabling worldwide communication between air and ground stations [10]. The aircraft's communication equipment spans the frequency spectrum to include: Very Low Frequency (VLF), Low Frequency (LF), Medium Frequency (MF), High Frequency (HF), Very High Frequency (VHF), Ultra High Frequency (UHF), Super High Frequency (SHF), and Extremely High Frequency (EHF) [24]. Figure 3 is a picture of the E-4B aircraft.



Figure 3. E-4B NAOC

From <http://www.af.mil/shared/media/photodb/photos/020925-F-9999s-0030.jpg>

Operators and maintainers are constantly performing at high standards to ensure E-4B aircraft are available for missions. Some missions arise with no notice, and it is sometimes difficult to have an aircraft available when one aircraft is required to be on alert and others are being modified. The aircraft modification schedule has created challenges due to schedule delays. The aircraft schedule is as important as the aircraft itself. Without an efficient schedule, the aircraft can be useless and even cost more to operate than it should. Key E-4B specifications are referenced in Table 3.

E-4B Aircraft Specifications	
Primary Function	Airborne operations center
Builder	Boeing Aerospace Co.
Power Plant	Four General Electric CFG-50E2 turbofan engines
Thrust	52,500 pounds (23,625 kilograms) each engine
Length	231 feet, 4 inches (70.5 meters)
Wingspan	195 feet, 8 inches (59.7 meters)
Height	63 feet, 5 inches (19.3 meters)
Maximum Takeoff Weight	800,000 pounds (360,000 kilograms)
Endurance	12 hours (unrefueled)
Ceiling	Above 30,000 feet (9,091 meters)
Unit Cost	\$258 million
Crew	Up to 114
Date Deployed	January 1980
Inventory	Active force, 4; ANG, 0; Reserve, 0

Table 3. E-4B Specifications
After www.fas.org/nuke/guide/usa/c3i/e-4b.htm

The E-4B Advanced Airborne Command Post aircraft was the culmination of the Cold War between the United States and the Soviet Union. During the Cold War, both countries had nuclear missiles aimed at each other on constant alert. This posture made it necessary for the United States to create a redundant mobile command post in the event that ground infrastructure sustained damages [16].

Codenamed “Nightwatch”, Boeing developed the E-4A aircraft from a 747-200 airframe that did not make it to the private sector. Operated by the United States Air

Force, these aircraft were specifically fabricated to function as a survivable mobile command post to provide the National Command Authority (NCA) with retaliatory strike capabilities. Destined to be the replacement for the then used NEACP EC-135J model, the E-4A model contained the same equipment as the EC-135J; however, that is where the similarities stop. The platform boasted three levels of amenities which included a briefing room, conference room, and individual department areas. With a respective minimum and maximum crew of 60 to 114 personnel, the aircraft housed the largest crew of any aircraft in United States Air Force history [16].

In 1979, the Air Force introduced the E-4B model which displayed a “hump” on the aircraft’s dorsal surface immediately behind the flight deck. The hump housed an SHF satellite antenna which exponentially increased communications capability. By 1980, the new E-4B model would become standard as the previous E-4A models were modified to become E-4B models [16].

Typical of many DoD acquisition programs, the E-4B aircraft is no stranger to funding deviations that result in programmatic gains or losses. This fact could not be truer, especially in a time when the DoD is trying to restructure its forces and assets in order to meet the nation’s military and political objectives with a shrinking pool of resources. While this may be the case, it is evident the nation possesses certain military assets that should not be considered as quick collateral off-set in order to divert funds to other acquisition programs.

Since 1974, the E-4B fleet has faithfully stood watch 24/7 as it flawlessly executed its role as the nation’s mobile strategic and tactical command and control nerve center. The support provided by the fleet of four aircraft has never been needed more than is exhibited in today’s political climate. With a steady influx of rogue nations, namely Iran and North Korea attempting to procure WMD, it is paramount that the United States maintains certain assets that have proven to be reliable over the years. The time will come when it is necessary to upgrade and transfer from one weapon system to the next; however, the acquisition of such assets must not be accomplished with haste.

According to the Air Force Fiscal Year 2008/2009 RDT&E Volume III Report, the goal of the E-4B NAOC modernization program is to ensure the fleet of highly

modified Boeing 747-200 maintains the most current technological systems on board one of the nation's key mobile assets in the threat against a nuclear attack. The upgrades to the E-4B platform will insert new capabilities and also enhance its reliability in two primary missions: providing 24/7 response for nuclear command and control duties as well as senior national leadership support. The fleet of four E-4Bs fulfills the role of satisfying DoD's requirement for an alternative support operations infrastructure for the National Military Command Center (NMCC) which is permanently located in the Pentagon. The E-4B NAOC fleet also satisfies the military need of an airborne operations center with communications capabilities that will permit national leadership to monitor and control military and civil national assets during all phases of national conflict or disaster. Development modifications include, but are not limited to, navigation systems (with their associated communications equipment), operations center facilities, equipment, and communications upgrades necessary for the E-4B fleet to execute its primary mission as an alternate NMCC [23].

2. E-3 Aircraft – Cost / Performance Specifications

The E-3 is estimated at having a unit cost of \$270M each and has received additional modifications to keep its system more advanced than the threats currently faced [26]. The program is scheduled to have a service life through 2025. The programs needed to sustain the aircraft range from \$300K to \$120M each. There are over 66 upgrades needed, and the Air Force has prioritized them based on immediate needs.

The E-3 "Sentry" AWACS aircraft ensures United States and North Atlantic Treaty Organization commanders have command, control, communications, and all-weather surveillance of the air [26]. This aircraft has played a dominant role in battle management, and it doesn't have a rival in the air at this time. It proved itself in previous conflicts including Desert Storm and is currently being used for the Global War On Terrorism (GWOT). The aircraft has also been performing state-side missions patrolling the United States' coast and large cities during big events. The aircraft were used during

and after Hurricanes Katrina and Rita and are heavily relied upon for various types of missions. Figure 4 is a picture of a United States Air Force E-3 aircraft.



Figure 4. United States Air Force E-3 AWACS
From <http://www.mdc.com/companyoffices/gallery/images/infoelect/usawacs1.html>

The E-3 AWACS aircraft is a heavily modified Boeing 707 commercial aircraft with a 30 foot rotating dome attached above the rear fuselage. The dome is six feet thick and houses the radar system that allows the aircraft to monitor from the surface to the stratosphere for more than 200 miles for targets that are low or high flying [26]. One clear advantage the E-3 has over ground based radar systems is that with its identification friend or foe system, it can make a clear determination of enemy and friendly aircraft that would challenge ground based radar systems.

The E-3 has many navigation, communication, and computer modifications that allow it to perform its mission. Various consoles are provided for operators to utilize the aircraft's system and direct, control, and notify friendly forces of dangers that may be present. The aircraft has a major advantage while in the air due to the fact they always

have fighter aircraft that escort them and are at their discretion to confront any enemy aircraft they may see them as a huge target.

The E-3's radar system has been proven to counter enemy jamming devices and continues to perform effectively in various deployments [26]. The aircraft has many crewmembers in the command and control area looking at various sections of the sky, and the aircraft is able to change its mission course at any time to decrease its chance of coming close to enemy aircraft or other threats. The aircraft is also capable of flying more than eight hours without refueling and can fly longer due to its in-flight refueling capability.

The E-3's stateside home base is Tinker Air Force Base in Oklahoma City, Oklahoma. This is an ideal location for maintenance purposes and also enables the E-3 to access depot facilities with ease. The E-3 aircraft currently undergo programmed depot maintenance every four years to ensure the aircraft are ready for their missions. The aircraft operate all over the world and also have operating bases at Kadena Air Base, Japan and Elmendorf Air Force Base, Alaska.

The E-3 has had a safe record with the exception of one aircraft being lost on takeoff from Elmendorf Air Force Base, Alaska. The aircraft encountered a flock of geese that went through the engines and caused the aircraft to lose power. All crewmembers aboard the aircraft were killed, and the crash forced the Air Force to adopt strict rules for dealing with migrating birds as well as placing preventive measures in place to eliminate birds from staying near active runways. The important E-3 specifications are outlined in Table 4.

E-3 Aircraft Specifications	
Primary Function	Airborne surveillance, command, control, and communications
Contractors	Prime: Boeing Aerospace Co. Radar: Northrop Grumman
Power Plant	Four Pratt and Whitney TF-33-PW-100A turbofan engines
Thrust	21,000 pounds each engine
Length	145 feet, 6 inches (44 meters)
Wingspan	130 feet, 10 inches (39.7 meters)
Height	41 feet, 4 inches (12.5 meters)
Rotodome	30 feet in diameter (9.1 meters), 6 feet thick (1.8 meters), mounted 11 feet (3.33 meters) above fuselage
Speed	Optimum cruise 360 mph (Mach 0.48)
Ceiling	Above 29,000 feet (8,788 meters)
Maximum Takeoff Weight	347,00 pounds (156,150 kilograms)
Unit Cost	Approximately \$270 million
Crew	Flight crew of four plus mission crew of 13-19 specialists (mission crew size varies according to mission)
Date Deployed	March 1977
Inventory	Active force, 33; Reserve, 0; ANG, 0
Losses	An E-3 crashed 22 Sep 1995 in Alaska, reducing the US fleet by one

Table 4. E-3 AWACS Specifications
After www.fas.org/man/dod-101/sys/ac/e-3.htm

The E-3 AWACS are scheduled to continue receiving modifications and programmed depot maintenance until 2018. By 2025, the fleet is scheduled to only have five aircraft remaining. The Air Force has been planning the replacement aircraft for many years and was going to combine two battle management aircraft onto one aircraft designated as the E-10. This aircraft has since seen funding reduced to provide money for other programs that have an immediate need.

3. E-8 Aircraft – Cost / Performance Specifications

The E-8 JSTARS aircraft reportedly costs \$244.4M in fiscal year 1998 dollars [1]. The first two E-8 aircraft were converted from used Boeing 707 airline platforms, but the problems that were encountered during the process prompted the Air Force to procure new Boeing 707 aircraft for the remaining aircraft. This decision increased the E-8 costs due to the production gap in the Boeing 707 line. The Boeing 707 production line was stopped three years before the Air Force decided to purchase new Boeing 707s. The Air Force researched additional aircraft to use instead of having Boeing reinstate the 707 production line, but the Boeing 707 was the lowest cost, and other platforms could have placed the program at risk [27].

The E-8 JSTARS is also an Air Force battle management aircraft that is capable of command and control, intelligence, surveillance and reconnaissance. The primary mission of the aircraft is to ensure friendly ground forces are provided with accurate information of enemy ground forces in a theater of operations [1]. The E-8, similar to the E-3, utilizes a Boeing 707 platform. The aircraft has also been heavily modified with a vast array of radar, communications, and operations systems to perform its unique mission. The E-8 has a radome beneath its fuselage that contains a 24-foot long radar antenna. The radar can obtain key information on ground forces that can be quickly sent to commanders for critical decision making [27]. The antenna primarily is used to detect ground forces, but it also has the capability to detect low, slow moving fixed wing aircraft, helicopters, and rotating antennas. The unique capability of the E-8 has allowed it to earn its spot in major conflicts and peacekeeping operations. Figure 5 is a picture of a typical E-8 aircraft.



Figure 5. E-8 JSTARS

From http://www.af.mil/factsheets/factsheet_media.asp?fsID=100

The E-8 aircraft is operated by the 116th Air Control Wing located at Robins Air Force Base, Georgia. The wing is known as “America’s First Total Force Wing” due to it being the first Air Force unit to consist of active and guard personnel working together with a single chain of command [1]. The aircraft are permanently based in Georgia; however, similar to the E-3, they operate at forward operating locations continually to assist in various conflicts. The E-8 specifications are identified in Table 5.

E-8 Aircraft Specifications	
Aircraft	Boeing 707-300 series aircraft, modified by Northrop Grumman Designation E-8A for two prototype aircraft Designation E-8C for one test aircraft and all production aircraft
Primary Function	Ground Surveillance
Contractor	Northrop Grumman Corp.
Power Plant	Four JT3D engines
Weight	171,000 pounds (Empty) 155,000 pounds (Max Fuel) 336,000 pounds (Max Gross)
Length	152 feet 11 inches (46.4 meters)
Wingspan	145 feet, 9 inches (44.4 meters)
Height	42 feet, 6 inches (12.9 meters)
Speed	.84 Mach
Ceiling	42,000 feet
Range	11 hours – 20 hours with air refueling
Unit Cost	\$225 million
Crew	Standard Mission: 21 (18 operators and 3 flight crew) Long Endurance: 34 (28 operators and 6 flight crew)
Date Deployed	1996
Inventory	Active force, 16; ANG, 0; Reserve, 0

Table 5. E-8 Specifications
After <http://www.globalsecurity.org/intell/systems/jstars.htm>

C. POTENTIAL REPLACEMENT AIRCRAFT FOR COMMAND AND CONTROL MISSIONS

The Air Force is currently facing a situation where there is a need to re-balance its forces while attempting to modernize their aircraft fleet. As stated previously, the Air Force's EC-135 aircraft were retired after the Navy upgraded their EC-130 aircraft to E-6 aircraft. The Navy's E-6 aircraft were newer, more efficient, and had better communication capabilities than the Air Force's older EC-135 aircraft. The Air Force could be placing their additional command and control aircraft at risk if they don't upgrade their aging fleet in the near future. Some foreign militaries have been procuring

command and control aircraft faster than the United States. Japan is one country that has decided to modernize one of their command and control aircraft. They have elected to procure Boeing 767 AWACS aircraft for their Air Defense Force. The 767 is more economical than the United States Air Force's E-3 AWACS that utilizes an older Boeing 707 platform. The specific mission equipment is similar, and the 767 AWACS is compatible with existing aircraft presently used.

Boeing has other aircraft that are being developed to replace additional aging aircraft. The 737 platform has been chosen to provide additional command and control capabilities to militaries around the globe. The United States Navy has also initiated a contract with Boeing to replace their P-3 aircraft with 737 P-8 aircraft. Previously, the Navy replaced their EC-130 aircraft with E-6 aircraft and eventually gained the former Air Force "Looking Glass" mission. The Air Force does not have a specific mission that correlates to the Navy's future P-8 aircraft; however, the Air Force should monitor the Navy's actions to prevent losing future missions. The 737 platform could be used as an Air Force command and control aircraft. It is smaller than existing aircraft the Air Force is using, but it should be evaluated to determine if the Air Force could utilize the aircraft to relieve pressures from its aging fleet. The Air Force may be able to reduce some costs since Boeing has an existing contract to provide aircraft to the Navy.

1. Boeing 767 – Cost / Performance Specifications

Passenger Boeing 767 aircraft prices range from \$124.5M to \$169M depending on the size aircraft purchased. The Japanese AWACS was based on a 767-200 airframe, and the E-10 was based on the 767-400ER version. The Air Force paid approximately \$2.058B for the development of one E-10A aircraft and needed approximately \$1.295B to complete the program. Figure 6 outlines the E-10A program performance.

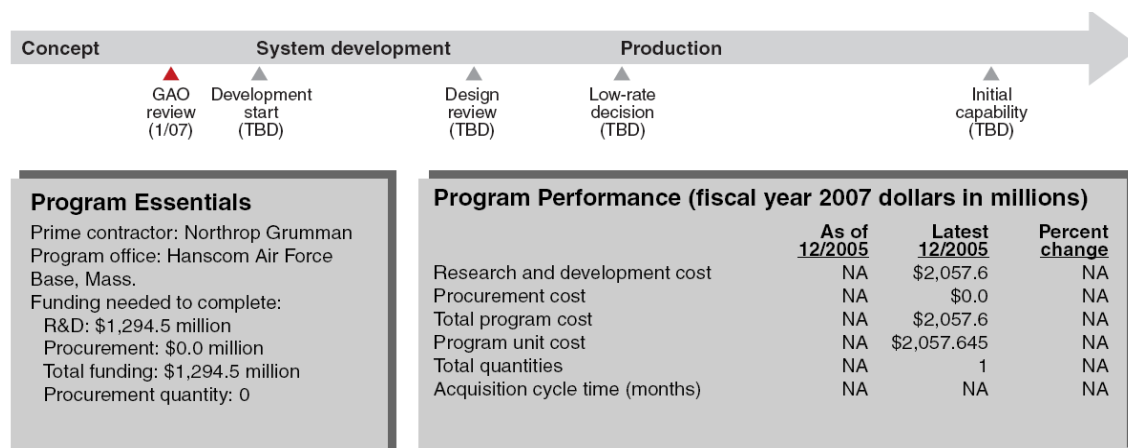


Figure 6. E-10A Program Performance
 From <http://www.gao.gov/new.items/d07406sp.pdf>

The Boeing 767 aircraft are heavily utilized by airlines. More than 125 operators have flown over 900 total aircraft over 27B miles on 7.7M flights. The aircraft was the first wide body aircraft certified for two person flight deck crews. It also shares a common certification with the Boeing 757. This could be beneficial for the Air Force since it presently operates Boeing 757 aircraft [28].

The Boeing 767 AWACS aircraft utilizes the previous research and developmental processes that made its predecessor, the Boeing 707 AWACS, a proven performer for airborne warning and control systems. Japan is the first country to order the aircraft, and the aircraft will be used for its tactical and air defense military forces [29]. The unique surveillance system utilizes a multi-mode radar that can distinguish land, sea, and air targets separately from ground and sea clutter. The system can detect and define targets with a 360-degree view more than 200 miles away when at mission altitude. Figure 7 is a picture of a Japanese Boeing 767 AWACS.



Figure 7. Japan Boeing 767 AWACS

<http://www.mdc.com/companyoffices/gallery/images/infoelect/767aw1.html>

The 767 offers various advantages over the existing 707s in the United States and other military aircraft fleets. The first advantage of the 767 is a 50 percent increase in interior space than the 707. It can also carry more weight a longer distance than the existing 707 aircraft. The aircraft is more fuel efficient and will utilize computers to reduce the flight deck crew to a minimum of two people. Many commercial airlines utilize the 767, so standard parts and maintenance should not be a problem wherever the aircraft travels [29].

Japan received four aircraft between 1998 and 1999, and the aircraft were all operating by 2000. Radar system improvements will be provided to keep their mission critical systems operating effectively. The improvement will increase the already sensitive radar to an even higher level. The radar system will be able to track and identify smaller targets as well as increase the system reliability. These updates will make the system similar to what the United States and other foreign militaries utilize in their existing AWACS aircraft.

One major advantage of the 767 AWACS is that it is interoperable with the existing E-3 AWACS fleet. The ability to interoperate strengthens the capabilities of each individual nation while allowing the countries to promote regional stability [29]. The E-3 AWACS has been a dominant player in contingencies allowing the United States

and friendly countries to develop and maintain air superiority. In order to maintain dominant control of the air, the United States and allied countries must ensure their fleets are mission ready and capable for future needs. The Boeing 767 is a platform that can ease the transition from aging aircraft to a newer one without sacrificing mission effectiveness. The Boeing 767 specifications are identified in Table 6.

Boeing 767 AWACS Aircraft Specifications	
Primary Function	Airborne surveillance and command, control, and communications
Model	767-200 (basic airplane); 767-27C (modified for 767 AWACS configuration)
Power Plant	Two General Electric CF6-80C2B6FA engines, 61,500 pounds thrust
Dimensions	Airframe – span 47.57 meters (156 feet, 1 inch); length 48.51 meters (159 feet, 2 inches); height 15.85 meters (52 feet) Radome – diameter 9.1 meters (30 feet); thickness 1.8 meters (6 feet)
Speed	More than 800 kilometers/hour (500 miles/hour)
Service Ceiling	10,360 meters to 12,222 meters (34,000 to 40,100 feet)
Endurance	9.25 hours on station at 1,000 nautical-mile radius; 13 hours at 300-nautical mile radius. Extended operations possible with air refueling
Range	10,370 kilometers (5,600 nautical miles)
Armament	None
Crew	Twenty-one (two flight crew, 19 AWACS mission specialists)
Maximum Takeoff Weight	175,000 kilograms (385,000 pounds)

Table 6. Boeing 767 AWACS Specifications
After <http://www.boeing.com/defense-space/ic/awacs/767/767specs.html>

The Boeing 767 is also being used and offered as a tanker variant. Italy and Japan have four aircraft each on contract that are scheduled to be delivered in 2008. The aircraft is also competing for an Air Force contract that should be announced in late 2007 or early 2008. The Boeing 767 aircraft has a strong presence in the civilian industry, but it is also gaining attraction by various militaries to upgrade their fleet and increase their capabilities.

In the context of the future integrated battlespace, the capability to deliver, receive, and process information will be a key asset. These very capabilities will determine how battles are fought, winners and losers are made, and how lives are lost or saved. The E-10A Multi-sensor Command and Control Aircraft (MC2A) could have very well been that key component the Air Force was looking for to bring operational command and control capabilities to the joint warfighter [30].

On August 18, 2003, the Air Force awarded Boeing a \$126M contract to purchase the first of five 767-400ER aircraft to be reconfigured as E-10A MC2A platforms. Although the sole source contract was not-to-exceed its \$126M value; final prices were subjected to negotiation. The initial 767-400 ER platform was purchased to function as a testbed platform in the E-10A program. By utilizing the 767 airframe and following Federal Aviation Administration certification rules, the Air Force was following government protocol by maximizing tax payer dollars to leverage commercial technology [31].

The E-10A was being developed to replace the E-3 AWACS, E-8 JSTARS, and RC-135 Rivet Joint aircraft. The aircraft utilized a Boeing 767 platform and had more space while allowing more efficient operations to support command and control missions. The aircraft was to employ upgraded communication suites that allow the Air Force to combine two separate missions on one platform [32]. By using one platform, the Air Force could potentially save money on maintenance, operation, and training required to support missions. One downfall to utilizing one large multi-role aircraft is the fact the aircraft will continue to be a low-density high-demand asset. The costs are lower, but the aircraft will have to be utilized continuously around the globe. Depending on the size of the fleet of E-10 aircraft, the aircraft could be based at a single stateside location to consolidate personnel and equipment to increase cost savings. Figure 8 is a concept drawing of the E-10A aircraft.



Figure 8. E-10A

From http://www.mdc.com/companyoffices/gallery/ids_surveillance.html

The contract stipulated that Boeing would build the 767 in its Everett, Washington plant. The platform would then be modified into the E-10A at Northrop Grumman's plant in Lake Charles, Louisiana. Eventually, the Air Force planned to procure four more E-10A MC2As by 2012 with the fleet increasing to 60 by 2020. The testbed was scheduled for delivery to the Air Force in December 2005 with the contract period of performance extending to December 2008 providing additional test-bed support past the deliver date. Evolution of the E-10A production process was scheduled to occur utilizing a two-stage incremental development approach. This approach guaranteed that the platform would not enter increment two until increment one was successfully completed. This approach was engineered to exploit capabilities while reducing cost [31].

The E-10A was considered the next generation surveillance/command and control platform. While Boeing was contracted to build the platform, Northrop Grumman was hired to modify the platform with advanced air and ground surveillance radar, high-processing capacity computers, and communication suites providing a robust battle management capability. The platform would integrate the Multi-Platform Radar

Technology Insertion Program (MP-RTIP) Wide-Area Surveillance (WAS) sensor and the Battle Management Command and Control systems into a single airframe. The suite of systems would provide a combination of cruise missile defense, moving ground target tracking, and dissemination of time-sensitive information. Much of the system capabilities already in use on the AWACS and JSTARS platforms can be upgraded and installed on the E-10A aircraft [30].

The E-10 has become a victim of the Air Force's decreasing budget. In August, 2006, the Air Force announced it would no longer procure the aircraft and would instead utilize the Northrop Grumman RQ-4 Global Hawk with upgraded sensors and the existing E-8 JSTARS aircraft for existing missions [32]. Additional funding would be beneficial to continue development and future production of the aircraft to fulfill current and future command and control aircraft requirements.

2. Boeing 737 – Cost / Performance Specifications

The Air Force currently operates C-40B/C aircraft that began operations in 2003. The aircraft costs an estimated \$70M each [33]. Despite being similar in price, they have different missions, so prices may vary slightly depending on what configuration the aircraft is in. The C-40B is for combatant commanders and is equipped with a communication suite that costs more than the standard equipment on the C-40C. The C-40C is equipped for carrying from 42 to 111 passengers. The Air Force would need the \$70M for the aircraft procurement and also budget additional modification dollars for needed command and control equipment that would be installed.

To develop the P-8 Poseidon, Boeing was awarded a cost-plus-award-fee contract worth \$3.889B to develop the platform. The aircraft procurement piece of the acquisition process is estimated to be worth \$20B while the total cost of the entire program is estimated to reach about \$44B (then year dollars) for an anticipated 25 year total life cycle. Also included in the platform's budget is \$100M for MILCON. Compared to the P-3, the Poseidon's larger size dictates an upgrade to current Navy infrastructure for the

Poseidon to operate. According to the Navy, the \$100M is a modest estimation of what it would cost to upgrade its four major operating sites to accommodate the larger Poseidon [2].

The Boeing contract called for 108 P-8s to replace 196 P-3 aircraft. The rationale behind the smaller number of aircraft was due to the fact that the service had hopes of also purchasing the Broad Area Maritime Surveillance Unmanned Aircraft System (BAMS UAS) system to augment the smaller fleet of P-8s [2]. The flyaway cost is estimated at \$17.274B with a unit cost of \$159.9M. At this cost, the P-8 program is meeting or exceeding all baseline cost objectives [34].

The March 2007 GAO Defense Acquisition report stated that as of June 2006, the P-8A Poseidon program is on budget and on schedule. Measured in fiscal year 2007 dollars, the program performance schedule indicates minimal changes requiring program funding. For a program of this magnitude, the P-8's performance and budget schedules are nothing short of impressive [35]. In May 2004, the P-8 entered the SDD phase with none of its four critical technologies meeting the production schedule, but the P-8 program is still on schedule to meet its minimum milestone requirements. This was made possible because contingency protocols required the insertion of backup technologies for such a scenario [35]. The P-8's schedule and performance are detailed in Figure 9.

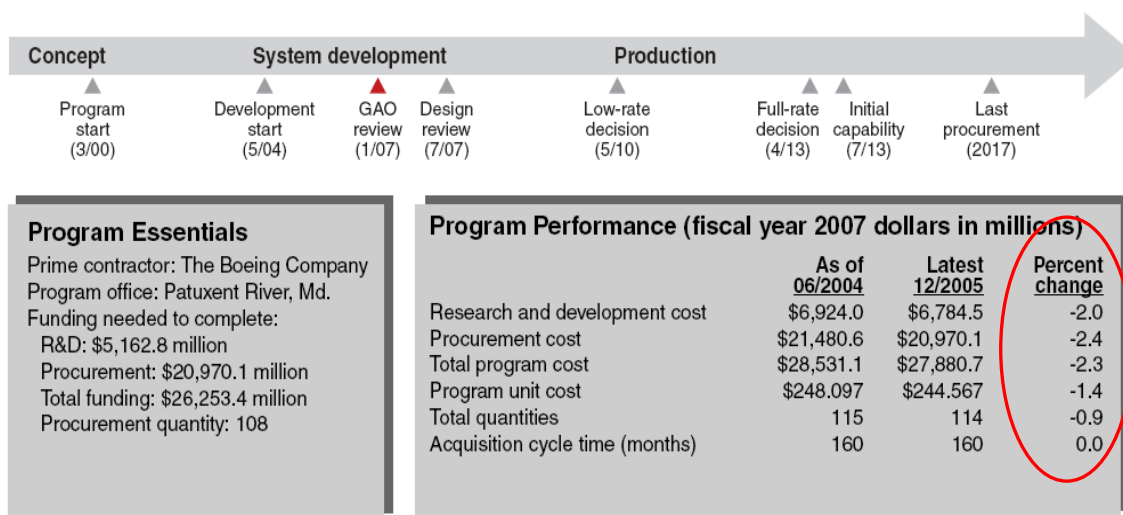


Figure 9. P-8 Production and Budget Schedule (GAO March 2007 Report)
From <http://www.gao.gov/new.items/d07406sp.pdf>

Historically, the Navy has great experience developing aircraft. In 1944, the United States Navy took the lead initiative and introduced a program aimed at developing the first fleet of aircraft equipped with airborne early warning radar systems. In 1945, the Navy converted a fleet of twenty new B-17Gs aircrafts into PB-1W. The PB-1W configuration called for the removal of all armament, permanent closure of all bomb bays, and installation of a search radar [36].

From 1945 through 1962, the Navy's airborne early warning mission transitioned to various aircrafts in the service inventory. In June of 1962, the mission was assumed by Lockheed's P-3 Orion and for the next 45 years, different variations [P-3A, P-3B (L), P-3B (H), P-3C] of the P-3 flew the airborne early warning radar systems. Through the years, the P-3 Orion and its many variants have proven to be an important asset ensuring the Navy's mission of securing national defense [37].

Although the P-3 Orion has been a dependable workhorse, the aircraft's dependability and longevity comes with increased maintenance cost, antiquated equipment, system interface restrictions, and lack of reliable parts due to its age. To replace its aging fleet of P-3 Orion, the Navy sought a new platform that would allow it to fulfill multiple maritime mission capabilities, so the platform was tentatively named the Multi-mission Maritime Aircraft (MMA). The MMA would require enough capacity to allow the platform to interface state-of-the-art technology with changing military doctrines capable of meeting new and emerging world threats. Figure 10 is a picture of two P-3 aircraft that the P-8 will replace.



Figure 10. Navy P-3 Orion
From <http://www.fas.org/man/dod-101/sys/ac/p-3.htm>

On June 14, 2004, the Navy signed a contract with Boeing's subsidiary company, McDonnell Douglas Corporation, to produce a replacement for the service's fleet of P-3 Orions. The aircraft of choice was Boeing's 737-800ERX. As DoD's executive agency for designating and naming all aerospace crafts, the United States Air Force formally named the MMA as the P-8A Poseidon [38]. The decision moved the MMA program from the Technology Development (TD) phase into the System Development and Demonstrations (SDD) phase of the acquisition process. This phase of the acquisition cycle focused on developing a platform that will revolutionize the manner in which the Navy accomplishes routine operations, deploys its forces, trains mission ready personnel, and staffs its maritime and recon forces [39].

The Boeing 737 platform is a reliable aircraft that is widely used by commercial airlines, and the military has taken interest in using the aircraft for various airlift missions. The aircraft can also be used for command and control purposes, and even though no United States military service is using it in that manner, foreign countries including Australia, Turkey, and South Korea have purchased the aircraft for military

operations. The 737 Ground/Air aircraft that Boeing is marketing has a multi-role radar system that allows tracking at extended ranges of targets. The radar system is capable of tracking airborne and maritime targets simultaneously and utilizes an identification friend or foe system to determine the status of targets it acquires. The radar is a low drag component, and the aircraft is capable of directing fighter aircraft while consistently monitoring the area of operations similar to AWACS aircraft [40].

The aircraft can operate at altitudes of up to 41,000 feet and can fly at least 3,500 nautical miles between refueling points. The aircraft has minimum downtime requirements and has a worldwide supply of parts readily available. The aircraft's navigation and communication systems are state of the art and enable the aircraft to perform missions in various environments and conditions to accomplish the required tasks. A key aspect of choosing Boeing's 737 was the size of the airframe and its adaptability to sustain multiple configurations. The aircraft combines a proven airframe and efficient high-bypass turbo jet engines with state-of-the-art open face technology. The 737s fundamental architecture characteristics provide a contemporary and reliable airframe which can be outfitted with various suites of intelligence, surveillance, and reconnaissance equipment for multiple mission requirements.

The P-8 is powered by two CFM56-7 engines. The CFM56-7 engine is the result of a joint venture between Snecma Moteurs and General Electric Company. Each CFM56-7 engine will provide 27,300 pounds of takeoff thrust and Boeing contends that it is among the most reliable engine in production. To date, the engine has logged over 30M flight hours while preserving the industry record of .002 percent in-flight shut down rate for every 1000 hours of flight [35].

The P-8 platform will ensure the Navy's future ability to conduct long-range maritime mission. The P-8 is scheduled to be equipped with the latest Anti-Submarine Warfare (ASW), Anti-Surface Warfare (ASuW), and Intelligence, Surveillance, and Reconnaissance (ISR) sensors. In essence, the P-8 is considered a long-range ASW, ASuW, ISR aircraft with the capability to conduct broad-area, maritime and littoral operations [2].

The Poseidon's advanced logistical and technological systems will set it apart from any other aircraft in its class, and the P-8 is destined to become an integral key asset in the Navy's Sea Power 21 Sea Shield concept. The platform will provide constant ASW and ASuW while utilizing intelligence, surveillance, and reconnaissance capabilities to support Sea Power 21 Sea doctrine. In addition, the fleet will serve a pivotal role in the services Force Net architecture [2]. Figure 11 shows the various sections of the P-8 aircraft.

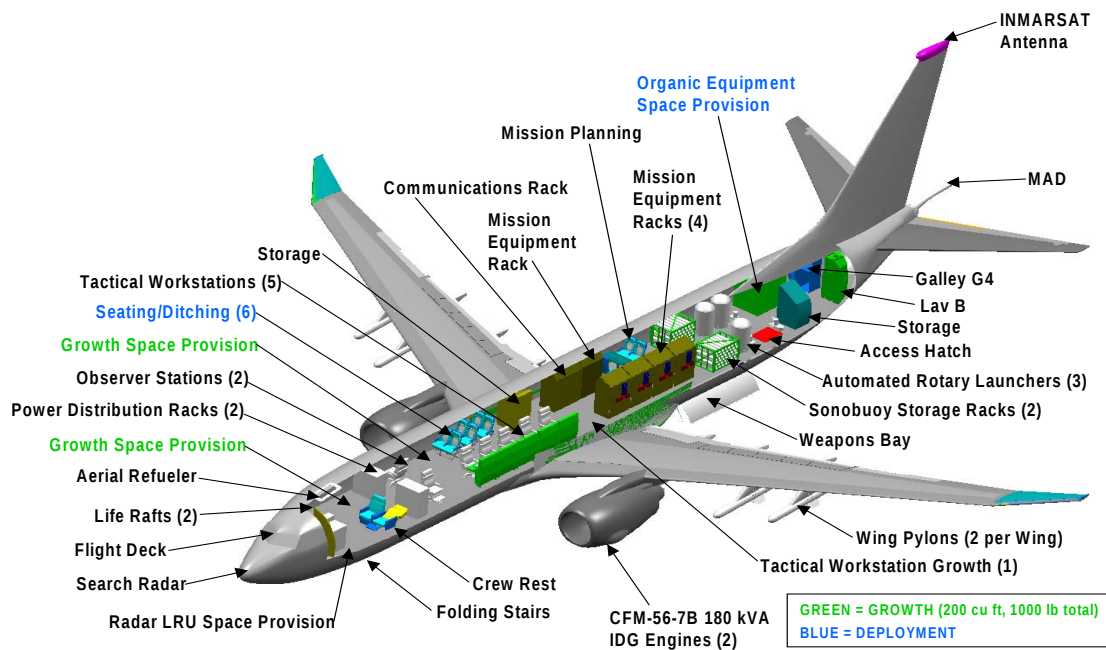


Figure 11. P-8A Fact Sheet Retrieved 7 October 2007 from <http://www.navair.navy.mil/mma/index.cfm?method=controller.about>

When compared side-by-side, the P-8's technological scales of economy are much more noticeable. Although the P-8 is 25 percent heavier than the P-3C, the P-8 carries one-sixth the fuel capacity, has two less and more efficient engines, provides greater operational mission range, and requires less manpower to operate; however, the benefit of technological advancement comes with a price.

Adjusting the P-3's fiscal year 1987 \$36M unit prices for 2004 constant dollar yields a price of \$52M. That number is the adjusted rate for what it would cost to replace one-single P-3C in 2004 dollars without the cost of inflation. When compared to the fiscal year 2004 \$159.9M constant dollar unit price of a P-8, the price of one P-3C must

be multiplied by a factor of three to get one P-8. The increased cost required to produce the P-8 is realized in the many technological advancements that shape the aircraft. The aircraft's value is realized when examining its payback or return on investment. In today's investment market, much more capital is required in order to make a product that requires less manpower, is maintenance friendly, energy efficient, and is adaptable for multi-purpose use. The P-8 embodies all of these attributes and more. The Navy was impressed with the platform and stated the P-8's Preliminary Design Review (PDR) that was completed from October 31 to November 4 of 2005 was "best major weapons system PDR it had ever reviewed [41]."

The Navy knows that it might end up paying a far greater price if the service does not begin major recapitalization efforts of its aging fleet. That cost will come at the expense of trying to maintain a technological advantage ahead of United States adversaries. Although that benefit comes at a higher cost, it outweighs the potential danger of continually using aging aircraft with rising maintenance costs, safety concerns, and decreased mission effectiveness. Table 7 shows a comparison between the P-8 and P-3C aircraft pertaining to cost and performance capabilities.

P-8 Poseidon		P-3C Orion	
Propulsion	2 hi-bypass turbofan engines rated at 27,000 pounds of thrust each	Propulsion	4 T56-A-14 Allison turbo prop 4,600 horsepower each
Length	123.3 feet	Length	159.2 feet
Wingspan	123.6 feet	Wingspan	99.6 feet
Height	42.1 feet	Height	33.7 feet
Gross Weight	187,700 pounds	Gross Weight	139,760 pounds
Speed	490 knots (564 mph)	Speed	330 knots (379.8 mph)
Range	1200+ nautical miles (1,381 miles) with 4 hours on station	Range	845 nautical miles (973.1 miles) with 3 hours on station
Fuel	10,000 pounds	Fuel	60,000 pounds
Ceiling	41,000 feet (12,496 meters)	Ceiling	28,298.6 feet (8,625 meters)
Crew	9	Crew	16 - 21
Unit Cost	\$159.9M (fiscal year 2004 constant dollars)	Unit Cost	\$36M (fiscal year 1987)

Table 7. P-8 and P-3 Comparison Chart

P-8 After <http://www.navair.navy.mil/mma/index.cfm?method=controller.about>

P-3C After <http://www.fas.org/man/dod-101/sys/ac/p-3.htm>

3. Boeing 787 – Cost / Performance Specifications

At this time, no cost is available for a military version 787. The military will have to use the pricing data and specifications outlined in Table 8 for any estimate as to how much the aircraft would initially cost. The 787 aircraft are priced from \$146M to \$200M. The additional cost of any modifications required for system installation as well as the cost of the equipment required would have to be factored in the overall cost of the program. The aircraft will be more expensive than a Boeing 737, but the overall life cycle savings must be calculated when more data becomes available.

Boeing	787-8	787-3	787-9
Passengers	210 - 250	290 - 330	250 - 290
Range (nautical)	7,650 to 8,200 nautical miles	2,500 to 3,050 nautical miles	8,000 to 8,500 nautical miles
Cabin Width	18 feet, 10 inches	18 feet, 10 inches	18 feet, 10 inches
Wing Span	197 feet	170 feet	203 feet
Length	186 feet	186 feet	206 feet
Height	56 feet	56 feet	56 feet
Cruise Speed	Mach 0.85	Mach 0.85	Mach 0.85
Max Takeoff Weight	484,000 pounds	364,000 pounds	540,000 pounds
Total Cargo Volume	4,400 cubic feet	4,400 cubic feet	5,400 cubic feet
Entry Into Service	November / December 2008	2010	Late 2010
Price in Millions	\$157 to \$167	\$146 to \$151.3	\$189 to \$200

Table 8. Boeing 787 Model Cost and Specifications
Retrieved after <http://seattlepi.nwsourc.com/boeing/787/787primer.asp>

After five years of high anticipation and aviation buzz, Boeing unveiled its newest commercial airline jet in 13 years. In 1994, Boeing introduced the 777 (Triple 7) to the world. Although technological advancements in the aviation world have grown exponentially, it seems that new platforms were competing on a two-dimensional scale: size and speed. Building it bigger and faster seemed to be the only way to outperform the competition. Boeing changed that with the introduction of its revolutionary platform to the aircraft industry [42].

On July 8, 2007 in Everett, Washington, the aviation spotlight was on Boeing as the world renowned aviation giant debuted its new 787 Dreamliner aircraft during an hour-long ceremony. The 787 Dreamliner is undoubtedly Boeing's most technologically advanced and environmentally friendly aircraft. The aircraft is being introduced as the "world's first mostly composite airplane [43]."

As of the debut date, 677 Dreamliner airplanes were on order from customers around the world earning the 787 the title of the fastest selling commercial air vehicle in history without leaving the ground. The honor of conducting the 787's series of certification flights will rest with Japan's All Nippon Airways since they are scheduled to

receive the very first 787 Dreamliner in May 2008. By the end of 2008, Boeing will have a total of six platforms being tested around the world [42]. Figure 12 is a picture from the 787 Dreamliner's debut ceremony.



Figure 12. Boeing 787 Debut Ceremony

From

<http://boeingmedia.com/imageDetail.cfm?id=14944&KeyWord=787&BuId=0&caid=0&prid=1985&sc=med&pn=1>

At the epicenter of the 787 is its fundamental open architecture concept. The simplified open architecture concept will radically improve systems functionality and integration. The concept is designed to facilitate the integration of the suite of new technologies being fielded by Boeing's global developmental team [44].

In its pursuit to produce what is arguably the most evolutionary commercial aircraft venture, Boeing harnessed the forces of the aviation industry to produce a platform that may not be matched for years to come. With an estimated cost of \$10B, if Boeing's venture does not break the bank, it certainly sets out to break new ground on

how and where commercial aircraft are designed, manufactured, and flown. Of particular notice is Boeing's decision to manufacture a commercial platform composed primarily of plastic [42].

The manufacturing and production process of the 787 is an intricate and complicated process that literally spans the globe on four continents. By Boeing's account, the 787 project is the biggest and most sophisticated industrialized venture in history with over a million hours of supercomputing design work utilizing the talents of hundreds of aerospace professionals from all over the world [42]. Figure 13 shows where various 787 components are manufactured.

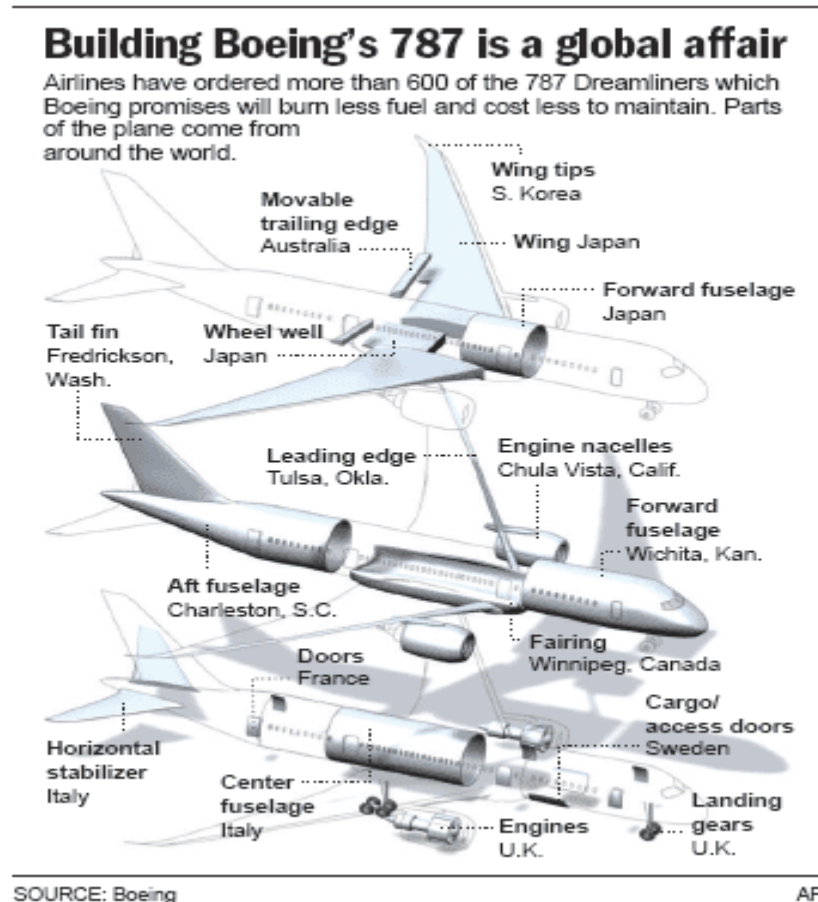


Figure 13. 787 Dreamliner Supplier Listing
Retrieved from <http://www.msnbc.msn.com/id/19421415/>

When it came to designing the Dreamliner, Boeing seemed to have re-written the traditional processes used in manufacturing commercial aircraft. To begin, past experience has shown that Boeing is traditionally a hands-on company which preferred maintaining full control over every detail of the production process from the design stage to production. With the Dreamliner, Boeing retained only 30 percent of the traditional in-house design and building phase of the production process. The remaining 70 percent of the design and building process was contracted out to Boeing's 50 partners and top 135 suppliers on four continents. By sharing the workload, Boeing has essentially spread the risk associated with such a large and important venture with its partners. Listed among the risk-sharing partners are Japan which is responsible for producing wings, portions of the fuselage come from Italy and South Carolina, France is responsible for the landing gear, China produces rudders, and companies in both the United States and Great Britain will produce engines [42].

This massive undertaking is managed through the use of a Dassault database management software. The database enables the Dreamliner work sites located around the world with a virtual interface 24 hours, 365 days a year. This capability guarantees that all technicians and engineers have access to a single source of information with a common set of drawings. Once all sections are manufactured, they are flown into Boeing's Everett facility near Seattle, Washington on a modified 747 cargo aircraft where Boeing technicians will then conduct the final assembly [42].

The 787 airframe (outer skin and fuselage) is primarily a combination of composite plastics and aluminum. The 777 uses 12 percent composites where as the 787 uses about 50 percent of composite material. Composites weigh less, are stronger, and are less susceptible to corrosion. For composite materials, the aircraft utilizes carbon fiber reinforced plastics in certain sections such as the fuselage and wing. Through this process, Boeing can fabricate one-piece fuselage sections because fewer parts are needed and purge the aircraft of 1,500 aluminum sheets and approximately 50,000 fasteners. The use of composite material reduces weight standards and will result in 30 percent less maintenance cost since composite material possesses more corrosion-resistant qualities

when compared to aluminum [45, 46]. Figure 14 shows the location of composites and other materials used throughout the 787.

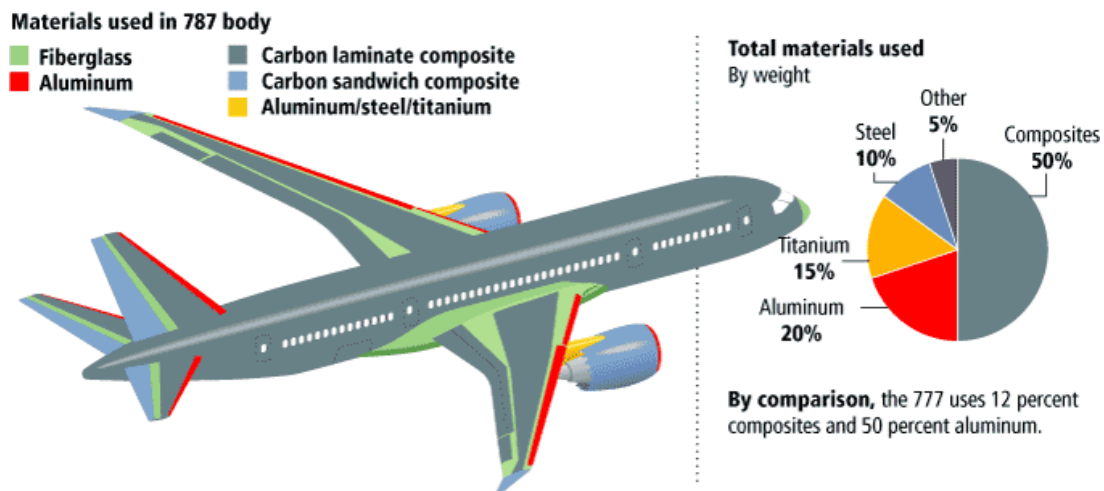


Figure 14. Boeing 787 Dreamliner Material Break-Down
From <http://seattlepi.nwsourc.com/boeing/787/787primer.asp>

The 787 power plant will be manufactured by two separate engine makers. Both Rolls Royce and General Electric will produce an engine that will be interchangeable at a moments notice. General Electric will supply the GENx (GE Next) and Rolls Royce will produce the Trent 1000. This will allow the 787 the unique characteristic of being equipped with either power plant at any time. Each engine will produce 55,000 to 70,000 lbs of thrust. The “bleedless” engines will utilize every ounce of air passing through it for engine functions which in turn will power the 787 electrical systems. Boeing expects the new engine technology to produce as much as eight percent of the aircraft’s overall increased efficiency. The transposable turbofan engines will be more fuel efficient than any previous wide-body aircraft engine [47].

The platform not only introduces the ranges realized by bigger jets to a mid-size airframe, but the fuel efficiency produced by the 787 will be unmatched by any aircraft of similar size. The end result of the increased fuel efficiency is an exceptional 20 percent reduction in harmful environmental emissions. The platform will consume 20 percent less fuel when compared to existing like aircraft while reaching speeds of Mach 0.85 [44, 45].

In an apparent bid to manufacture a platform that can serve various industry segments, Boeing will develop three versions of the 787. Although each version will vary by the number of seats, length, and range, the overall performance and cost savings achieved by the innovative platform will remain intact. Table 9 highlights the similarities and differences between the three planned versions. In addition to the 787-9, Boeing is working on the plans for a 787-10 stretch version. The 787-10 will accommodate over 300 passengers and it is being considered for a debut time-line of 2013 [48].

D. CHAPTER SUMMARY

This chapter identified the current command and control aircraft as well as potential replacement aircraft. The aircraft as well as their cost and performance specifications were presented to demonstrate the unique capabilities they each possess. It is important to keep the capability to perform the various missions they currently accomplish. The following chapter provides an analysis of the aircraft identified and provides advantages and disadvantages as well.

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III. ASSUMPTIONS AND METHODS

Command and Control aircraft play an integral role in the Air Force's ability to efficiently and effectively fight enemy forces. Without these special purpose aircraft, our fighter, tanker, and cargo aircraft would be at a severe disadvantage while performing their missions. Often, the aircraft are behind the scenes and may not get recognized unless something goes wrong; however, without them, the mission effectiveness of other aircraft would diminish.

A. MAJOR ASSUMPTIONS

In order for the research to accomplish specific objectives, certain assumptions were made. In particular, the researchers assumed readers were familiar with military structure and the dynamic environment associated with it; however, the researchers assumed the readers were unfamiliar with specific command and control aircraft and missions. The writers also assumed readers had a fundamental understanding of commercial aircraft that are modified and used in the military services. Technical performances were identified; however, the reader does not need to have a technical background to understand the purpose and intent of the research.

The researchers assumed the Air Force will eventually replace their command and control aircraft fleet. New technology continues to be fielded that may one day change how command and control missions are accomplished, but for the purpose of the project, the assumption was made that aircraft will continue to be used in command and control missions in the future. It was also assumed that aircraft priorities will continue to progress in a similar manner as in the past and that command and control aircraft will continue competing for funding against fighter and tanker aircraft.

B. ALTERNATIVE SOLUTIONS

The solutions that will be analyzed consist of retaining the E-4B, E-3, and the E-8 aircraft presently in service, or replace the current aircraft with either the Boeing 767, 737, or 787 aircraft. The solutions are identified as either retaining all existing command and control aircraft or replacing all command and control aircraft with one common platform. The Boeing 767 aircraft was chosen as a possible replacement because of its capability as well as due to the fact the Air Force may use the aircraft for tanker variants. The Boeing 737 will be used by the Navy for a command and control mission, so the aircraft could be a viable option for the Air Force to consider as well. The Boeing 787 is the newest Boeing aircraft being built. The aircraft is slated to be the most fuel efficient aircraft available, and it could be a good aircraft to help the Air Force lower operating costs.

C. SCOPE OF THE PROJECT

This MBA Project focuses on the Air Force's recapitalization options. There are an unlimited number of options available to perform command and control missions. Other aircraft available that are not analyzed include Boeing 757, 747, and 777 aircraft. No research was conducted on various Airbus aircraft available on the market as well. Unmanned aircraft capable of performing command and control missions were not researched but could be in future research projects. The project focuses on either retaining all command and control aircraft or replacing all of the aircraft with a similar platform for all missions. The researchers understand other options could have been to retain/replace certain aircraft and have a mixed fleet of aircraft.

D. ANALYSIS OF ALTERNATIVE SOLUTIONS

The Air Force currently has a fleet of command and control aircraft that are accomplishing their respective missions. The aircraft require ongoing modifications to keep the aircraft capable of accomplishing future missions. The Air Force must decide

whether to keep the existing aircraft (E-4B, E-3, and E-8) or to replace the aircraft with more modern aircraft available on the commercial market. The commercial aircraft available that could be modified and utilized for command and control purposes are the Boeing 767, Boeing 737, and the newest aircraft, the Boeing 787. These aircraft will require large financial obligations to procure, but they will enable the Air Force to successfully accomplish critical missions for years to come.

The E-4B is an aging aircraft that requires upgrades to keep it useful in today's environment. The Air Force has to analyze more than costs to determine what actions to take with the E-4B. The aircraft may be more expensive to maintain than other aircraft, but the capabilities of the aircraft need to be considered and factored in with any decisions that will be made concerning its future.

The E-3 AWACS has a proven track record. The aircraft has useful applications in military operations stateside and abroad, and only one aircraft has been lost during operations. This loss was the result of the aircraft encountering a flock of birds upon takeoff. The aircraft's proven performance and capabilities make the aircraft a valued asset in the Air Force inventory.

The E-8 aircraft is another proven performer in the Air Force aircraft fleet. The aircraft has an important mission that allows commanders to know what enemy movements are being made on the ground it is conducting surveillance over. The aircraft is also a member of the Air Force's High-Demand Low Density fleet of aircraft that are constantly tasked to perform throughout the world.

The E-10A (Boeing 767) platform was intended to be a key asset in the Air Force's Constellation concept providing joint warfighters with command and control capabilities by utilizing advanced sensors, sensor fusion, network-centric warfare and high-speed, wide-band communication systems. Unfortunately, the program was a testbed program that never made it to SDD due to budget constraints, and the program was terminated in order to ensure the viability of more pressing recapitalization projects.

Similar to other acquisition programs, the P-8 has seen and will continue to endure various forms of production delays. One such item was the design stability drawings. The GAO was unable to ascertain drawings to assess the program's design

stability; however, the P-8 program office anticipated that 80 percent of the drawing would be available to manufacturing at the time of the 2007 critical design review. In the March 2007 GAO report, the Navy stated the critical technology issues are continually being addressed and should be assessed at the critical design review planned for the third quarter of fiscal year 2007 [35].

If the P-8 Poseidon does not meet the expected production and budget schedule, the Navy will encounter negative implications that will have far reaching consequences. For one, without the P-8, the Navy will continue flying its fleet of aged P-3C Orion. History has shown that older aircraft are more expensive to maintain [35].

Another program that could affect the P-8 is the Navy's BAMS UAS. BAMS UAS is an integral part of the services efforts to recapitalize its maritime patrol and reconnaissance forces. BAMS UAS is meant to serve in a support role next to the MMA, but the program is two years behind schedule. If BAMS UAS remains behind schedule, the P-8 platform will have to fulfill that role as well, making it more critical for the P-8 to maintain schedule timelines [35].

There is still another program that is heavily reliant on the P-8 meeting production schedules. The Navy entered into a joint development contract with the Army to develop the Aerial Common Sensor (ACS). The ACS is an airborne surveillance asset that was scheduled to replace three current Navy systems including the EP-3 aircraft. In January of 2006, citing weight issues, the Army cancelled its portion of the ACS program. As a result, the Navy was left researching a replacement solution for the EP-3. One option considered was including the ACS equipment onto the P-8 platform [35].

Faced with variables, the Navy understands the importance of the P-8 Poseidon program coming in close to its projected production schedule. According to the GAO Report, the platforms design maintains 70 percent commonality with the commercial 737-800 platform and the detailed design drawings were 25 percent complete. The metrics used to measure drawing releases are defined and being utilized as an essential tool to assess system design maturity for the critical design review. The Navy agreed

with the GAO report and reiterated the P-8 Poseidon MMA program is on track with the baseline schedule and either meets or exceeds all cost, schedule, and performance parameters outlined in the baseline [35].

On October 10, 2007, Boeing announced that its 787 Dreamliner will suffer a six month delay. It seems a combination of events such as production delays, supplier mistakes, and lack of parts has chipped away at the project's margin of error. These unforeseen interruptions will prove problematic for the tight schedule, and the \$10B Boeing has invested in a program aimed at helping the aviation giant regain a leading position in the aviation industry [49]. Instead of its initial delivery taking place in May 2008, the event will not occur until November or December 2008, and the testing and certification phase will not take place until March 2009, which is six months behind schedule [49].

Although the 787 platform is plagued by delay issues, once the aircraft becomes fully operational, it will be difficult for aircraft in the same class to compete. That is evident in the fact that the 787 aircraft claimed the record for becoming the fastest selling commercial aircraft in history [49]. If there is a lesson here, it says that the private sector knows a good deal when it sees it.

1. Advantages and Disadvantages of Possible Solutions

- E-4B Advantages: The E-4B is a proven performer. It is a nuclear hardened aircraft that would be extremely expensive to build today. Despite the aircraft's age, it is still used for VIP travel abroad and is symbolic of our nation in a similar manner as Air Force One. The aircraft's key role during the Cold War makes it a talked about yet secretive aircraft. The various systems allow dignitaries to communicate around the globe on missions, and the aircraft's ability to refuel in-flight enables the aircraft to fly longer distances without having to land for fuel. This is a key advantage compared to the C-32A aircraft that was scheduled to replace the E-4Bs. The aircraft has received many modifications and already has people with proper

experience and training. The E-4B still has useful life on the structure, and research should be conducted to determine how expensive it will be to maintain the aircraft.

- E-4B Disadvantages: The E-4B has received numerous modifications and faced challenges having newer systems communicate with older systems. This challenge has forced the aircraft to go over budget on modification costs and made the aircraft receive attention as an expensive aircraft to maintain. Despite increased modification costs, operational costs are also more expensive than smaller, newer aircraft on the commercial market. The money saved by operating more efficient aircraft could be used to fund additional programs. The E-4Bs were initially produced in the 1970s. The structural age of the aircraft may have useful life remaining, but the aircraft will eventually require replacement or additional money to ensure a high level of mission capability.
- E-3 Advantages: The E-3's main advantages are similar to the E-4B. The aircraft has proven performance capabilities that are valuable in current operations. The aircraft has received many upgrades, and the aircraft has similar capabilities of newer aircraft foreign countries have procured. Personnel that operate and maintain the aircraft are already trained on how to properly utilize the various systems it has. Another advantage the E-3 has is that the aircraft are scheduled to receive upgraded engines that would decrease its fuel usage, improve mission capability rates, and allow the aircraft to takeoff and land on shorter airfields. The new CFM-56 engines would increase the per engine thrust from 21,000 pounds to 24,000 pounds. Saudi Arabia, United Kingdom, and France already have the CFM-56 engines on their E-3 aircraft [50]. An example of a Saudi Arabian E-3 with CFM-56 engines is in Figure 15.



Figure 15. Saudi Arabian E-3 With CFM-56 Engines

From <http://www.airforce-technology.com/projects/e3awacs/e3awacs8.html>

The E-3's engines (TF-33) have experienced increased depot overhaul costs. In 1996, the estimated cost of an engine overhaul was \$257,000 per engine; however, the costs continued to climb each year, and in 2006, the figures have escalated to \$1.25M per engine. The price increase was attributed partly to the fact the TF-33 engines are no longer widely used in aircraft fleets [51]. Once the engines are replaced, the Air Force should see operation and maintenance cost savings that can be allocated to other programs.

- E-3 Disadvantages: The E-3's aircraft systems are similar to other newer platforms that were recently purchased by the Japanese Defense Force. The challenging areas for the E-3 are with the age of the aircraft. The aircraft's engines are older and less efficient than what is currently available. In order to re-engine the aircraft, the aircraft would be unavailable for current operations around the globe despite being a part of the Air Force's High-Demand Low-Density aircraft. The aircraft will also have to compete for scarce funding for the engine and ongoing modifications currently planned.
- E-8 Advantages: The E-8 aircraft are the newest Boeing 707s in the Air Force inventory. With the termination of the E-10 program, the E-8 has become a possible recipient of the communication suite that was going to be installed in the E-10. The E-8, being the newest Boeing 707 in the Air Force fleet, should

be able to remain in the inventory for many years to come if it is allowed to have the upgrades to keep it operating effectively. The E-8's personnel are already trained and experienced in operating and maintaining it, and the E-8 has a solid support structure already in place. The E-8 program office is currently managing a re-engining effort for the aircraft. Once completed, this process will increase reliability, allow the aircraft to operate from more bases, allow a longer flight time between refueling needs, and lower environmental pollution [52].

- E-8 Disadvantages: One of the E-8's disadvantages could be its platform. The Air Force decided to procure the Boeing 707 for this mission in part due to the number of Boeing 707s in the inventory. The support structure was already in place, and flight crewmembers could be utilized from other aircraft already in service. When the Air Force decides what aircraft will replace the KC-135 aircraft, it could reduce the infrastructure in place to support the Boeing 707s in the Air Force fleet. This could set the stage for the E-8 to be less effective and have a smaller support structure to accomplish missions.
- Boeing 767 Advantages: The Boeing 767 offers key advantages over existing 707 aircraft in the Air Force fleet. First of all, the aircraft has 50 percent more floor space and almost twice the volume of typical the 707 platform. The 767 can carry more cargo and also fly a longer distance than the 707 [29]. The 767 utilizes a two person flight crew that will allow the Air Force to have smaller flight deck crews allocated for each mission. The 767 also offers economical advantages by using twin engines instead of four presently used on 707 aircraft. The 767 would require less aircraft to accomplish the mission and also a reduced number of tankers to remain airborne for mission operations. The aircraft would also require fewer crewmembers to accomplish a workload similar to missions requiring more crewmembers on older, E-3 aircraft currently used today.
- Boeing 767 Disadvantages: Despite the Boeing 767's advantages, it also has challenges the Air Force would face by deciding to acquire it. One major

challenge is dealing with the fallout that arose from the Air Force's decision and cancellation of the tanker lease program. The fact the 767 would be procured again could cause senior leaders to question the validity and need of the aircraft and require more extensive studies to ensure the aircraft is the best choice. Another challenge is the fact Boeing is producing the 787 aircraft that is stated to be more efficient and is scheduled to replace 767s in commercial fleets. If the commercial airlines reduce their number of 767s, less support will be available around the globe. The Boeing 737-900 is another competitor that is similar in size and possesses a cheaper price than the 767.

Although the Navy's eagerly anticipated P-8 Poseidon is essentially a commercial-off-the-shelf airframe, it seems the service could not have selected a better platform to invest in. The Boeing 737 aircraft combines a proven and dependable airframe with reliable high-bypass turbo fan jet engines. For the Navy's purpose, the seamless integration of aircraft, crew, and mission systems will significantly enhance its ability to accomplish ASW and ASuW operations. The platform provides the ability to have a greater range of mission, endurance, and payload [34].

Further analysis of the 737 platform suggests that the aircraft's specifications and characteristics make it a highly desirable platform suitable to accommodate a wide variety of mission roles. A key characteristic of any multi-role platform is its ability to be reconfigured for diverse mission requirements, and the Poseidon offers that flexibility. The platform's open mission system architecture makes it easy to expand or reconfigure installed systems, thereby reducing complications associated with system or workstation upgrades. Platform management is accomplished with a nine-person crew consisting of a dual-pilot cockpit, one relief pilot, one in-flight technician, and five mission crewmembers. While providing the same level of worldwide response mission requirements, the platform affords the feasibility of a smaller workforce while potentially requiring a smaller support infrastructure [34].

On July 5, 2006, Boeing unveiled its P-8 MMA mobile demonstration trailer in Renton, Washington. The trailer's main purpose is to provide a venue for hands on demonstration of the P-8's full spectrum of capabilities to the Navy, its team members,

and suppliers. The 53-foot long trailer contained a 737 commercial cockpit as well as interactive and fully functional operator workstations. The trailer was scheduled for a nine-week tour to different commands exposing personnel to the technology that will be integrated into the platform. This tool allows the Air Force the opportunity to scrutinize a demonstration model at virtually no cost. In addition, it may also be feasible to exchange the systems requirements that are unique to the Navy with those that are unique to the Air Force. The bottom line is that the existing demonstration platform would allow the Air Force the chance to examine off-the-shelf technology on a platform that is tested and proven.

- Boeing 737 Advantages: The Boeing 737 has a vast support structure in place globally due to its place in the civilian airline industry. If the aircraft had any mechanical problems, it should be able to utilize any support structure in place at airports around the globe. The Navy is also in the process of replacing its P-3 aircraft with P-8, Boeing 737 aircraft. The aircraft have mission critical systems, and the Air Force could utilize a similar costing structure the Navy used to possibly attempt to “piggyback” on the Navy’s existing contract. One advantage of the Boeing 737’s smaller airframe is that it could easily use existing runways and hangars the E-3 and E-8 aircraft presently use.
- Boeing 737 Disadvantages: The aircraft’s smaller size may not provide space for additional necessary modifications or the numerous crewmembers that currently fly on existing aircraft. Another disadvantage is that the Air Force does not have a large number of Boeing 737 aircraft in its inventory, so if the Air Force was going to use this aircraft, additional support equipment and infrastructure may be required.

Like any acquisition program, the P-8 has and will endure its fair share of programmatic set backs. In the acquisition world, improvement is measured by how successful a particular program is when it comes to meeting certain timelines or milestones in the acquisition process. When it came to the P-8, all four critical technologies were underdeveloped when it entered into production development in 2004. In regards to the general specifications of the 737, the airframe, avionics, and engines are

proven, and compared to other aircraft in its class, the 737 leads the pack. The only identifiable disadvantages can be attributed to the lack of maturity of certain critical technologies.

The 787 is a revolutionary aircraft that holds a stack of aviation “first” records. It holds the record to reaching the 500 order mark in the shortest time in commercial aviation history. It is the first to switch from metal to composite materials with the preponderance of its frame and shell built of composite material. The Boeing 787 has great potential and is expected to become a major platform in many commercial airlines.

- Boeing 787 Advantages: The 787 is the first platform built with a one-piece fuselage essentially reducing hundreds of pounds of metal nuts and bolts. It is also the first commercial aircraft to offer two engines with a standard interface allowing the use of any engine at any time. Collectively, the platform is expected to produce a 20 percent savings in fuel consumption and a 30 percent savings in maintenance. The platform has three variations which may be flexible to accommodate a variety of missions.
- Boeing 787 Disadvantages: With all the first place ribbons pinned on its wings, the 787 still remains an aircraft that must prove itself. As of October, Boeing’s \$10B investment still sat in a hangar with a six month delay in schedule while Boeing sorted out various logistical issues. That delay translates into a six month delay in flight certification, six month delivery delay to the customer, and six month delay in revenue earning potential. If the aircraft does make it off the ground and achieves air worthiness, the plane will still have to pass rigid military testing before being considered for military applications.

2. Procurement and Performance Analysis

The concept of comparing potential replacement and current aircraft is a difficult task to accomplish. Current inventory aircraft have a major advantage over potential replacement aircraft because inventory aircraft already have existing logistical support,

equipment, and infrastructure. Despite this advantage, current aircraft are aging, will require ongoing modifications to remain mission capable, and eventually will require replacement. The potential aircraft being evaluated includes Boeing's 767, 737, and 787 aircraft. The Boeing 767 data is similar to the E-10 aircraft based on a 767-400ER. The Boeing 737 data is similar to the Navy's P-8 aircraft which utilizes a 737-800 platform. The Boeing 787 information pertains to the 787-800 series aircraft that is currently being prepared to conduct airworthiness testing.

a. Criteria Measures

The quantitative data measured includes the initial procurement cost of each alternative aircraft. The costs consist of a standard aircraft (priced similar to airlines) as well as initial modification costs required to militarize the selected aircraft. The different aircraft compared give an approximate indication of how much the new aircraft would cost compared to the initial cost of existing aircraft in the command and control fleet. The potential aircraft uses dollar figures that are estimated to present a picture of the total cost of each aircraft. The cost of the Boeing 767, 737, and 787 aircrafts were taken from the cost of a standard passenger aircraft. Table 9 displays data that will be analyzed in the following paragraphs.

Potential Replacement and Current Aircraft Comparisons						
	767-400	737	787-8	E-4B	E-3	E-8C
PROCUREMENT COST COMPARISON						
Category	Potential	Potential	Potential	Current	Current	Current
Aircraft Costs	\$169M	\$70M	\$167M	-	-	-
*Modification Cost	\$125M	\$89.9M	\$125M	-	-	-
Total Unit Costs	\$294M	\$159.9M	\$292M	\$258M	\$270M	\$225M
PERFORMANCE COMPARISON						
Range	11.5 hrs unrefueled	6 hrs unrefueled	<u>14.5 hrs unrefueled</u>	12 hrs unrefueled	-	11 hours unrefueled
Max Takeoff Weight (pounds)	450,000	187,700	<u>484,000</u>	800,000	347,000	336,000
Cruise Speed (Mach)	0.76	0.74	<u>0.85</u>	-	0.48	0.84
Ceiling (feet)	38,000	41,000	<u>43,000***</u>	30,000+	29,000+	42,000
Wing Span (feet)	170.33	<u>123.60</u>	197	195.67	130.83	145.75
Length (feet)	201.33	<u>123.60</u>	186	231.33	145.50	152.92
Height (feet)	55.33	<u>42.10</u>	56	63.42	<u>**41.33</u>	42.50
Current aircraft are listed for reference purposes and not evaluated against potential replacement aircraft Boeing 767 data taken from Japan Defense Force AWACS information. Boeing 767 also has non-AWACS capabilities Boeing 737 data taken from Navy P-8 data. Boeing 737 has non-P-8 capabilities *Modification Costs only include initial modification estimates. Subsequent and on-going modifications are not included in calculations **Excludes rotodome that extends an additional 11 feet above aircraft ***From: http://www.plane-spotter.com/Aircraft/Boeing/787.htm Boxes with items in bold and underlined or with checkmarks are perceived as the best alternative						

Table 9. Potential Replacement and Current Aircraft Comparison Chart

The three aircraft being compared as potential replacements for the existing command and control aircraft are commercial aircraft that will require military modifications to accomplish specific missions. The initial procurement cost of each aircraft without modifications ranges from \$70M to \$169M. The 767 aircraft costs \$169M while the smaller 737 costs approximately \$70M. Boeing's newer 787-800 series aircraft costs approximately \$167M. The modification cost of the 737 was taken from the P-8 data research uncovered. The total cost of the Navy's P-8 is \$159.9M while the plain commercial configuration costs \$70M. The aircraft cost (\$70M) was subtracted from the total aircraft cost (\$159.9M) to arrive with a modification cost of roughly

\$89.9M. Due to the size differences between the 737 and both the 767 and 787 aircrafts, the \$89.9M was multiplied by a 40% differential estimate to arrive with \$125M for modification cost for both the 767 and 787 aircraft. The P-8 has the most current data available and represents a more accurate estimate of modification costs than attempting to take the initial modification cost of the existing aircraft since they were initially modified from 10 to greater than 30 years ago. Technology has changed that has decreased the cost and size of communication packages installed in newer aircraft.

Quantitative data was also analyzed to compare performance data of the potential aircraft. The range, maximum takeoff, and ceiling are values that have to be analyzed to ensure the best performance is being selected. From the previous price comparisons, the 737 seems like a logical choice since it had the lowest price; however, the aircraft selected needs more than a low price to be the best replacement for the existing command and control fleet. An aircraft this size would require additional logistical support in order to maintain current mission levels. An aircraft's range is an important performance feature that varies between services.

- The Navy's P-8 satisfies their requirement for shorter flights by being able to fly 6 hours un-refueled. The aircraft is capable of in-flight refueling, but the un-refueled range is displayed to demonstrate the range without using tanker support. The shorter the range of the aircraft, the more tankers will be required to allow the aircraft to perform its mission.
- The 767 has an un-refueled range of 11.5 hours. This is similar to existing command and control aircraft and would be extended with in-flight refueling capabilities. The E-10A aircraft that was being developed on the 767 platform was scheduled for in-flight refueling modifications, so it is assumed the aircraft used for command and control missions would be configured similarly.
- The 787 has the longest un-refueled range and can fly 14.5 hours before requiring additional fuel. From a range standpoint, the 767 and the 787 are capable of being used for command and control missions,

but the 787 can fly 3 hours longer than the 767 could ease the burden of using tankers and is thus the best choice for the range portion of performance comparisons. These additional 3 hours of flight time could translate into significant cost savings in terms of a decrease in refueling tanker support, less idle time waiting for refueling which in turn will increase mission effectiveness. This feature alone could also impact the number of replacement tankers needed for future procurement. Collectively, such savings multiplied over the life cycle of an aircraft would be considerable.

The maximum takeoff weight is another key performance characteristic to measure potential replacement aircraft. Command and control aircraft carry sophisticated communication equipment that adds additional weight to the aircraft. The aircraft are also loaded with large quantities of fuel to ensure the aircraft are able to accomplish their missions. These requirements make the maximum takeoff weight crucial to command and control aircraft, and potential replacement aircraft must be able to accommodate the weight demands placed on them.

- The 737's maximum takeoff weight is the lowest being compared at only 187,700 pounds. This is almost one-half of the weight of current command and control aircraft, and it is less than one-half the weight of other alternative aircraft being compared. According to this parameter, the 737 would not be able to fulfill the role of current Air Force command and control missions.
- The 767 aircraft has a 450,000 pound maximum takeoff weight which is more than the E-3 and E-8 maximum takeoff weights, so the aircraft could be considered a potential contender for command and control missions.
- Next to the E-4B, the 787 has the largest maximum takeoff weight at 484,000 pounds, so the aircraft would be the best alternative to the existing aircraft based on the data provided.

The ceiling is another performance characteristic that must be compared when deciding which potential aircraft to choose. The ceiling is the highest altitude an aircraft can attain while still performing its mission effectively. In general, the higher the aircraft ceiling, the safer the aircraft is from surface threats, and the aircraft is able to perform more efficiently at higher altitudes.

- The 767's ceiling is the lowest at 38,000 feet.
- The 737 can operate at 41,000 feet.
- The 787 has the best ceiling characteristic and can operate at 43,000 feet.

The wing span, length, and height are important characteristics because they determine whether or not a potential alternative is able to utilize existing facilities such as runways and hangars. If alternative aircraft cannot use existing base infrastructure, additional funding must be considered for possible modification or new construction base infrastructure.

- The 737 is a smaller aircraft than the current command and control aircraft, so the aircraft would not have a problem using current Air Force base infrastructure.
- The 767 aircraft is larger than the 737. Since the Air Force was engaged in the process of acquiring a line of 767 aircraft, it is assumed that the existing facilities housing the current command and control missions the 767 was meant to replace are adequate to host the aircraft, or that funding was set aside to construct adequate facilities. In addition, the 767 could also fulfill the mission of much larger aircraft. For example, the 767 could be stationed at Offutt Air Force Base, Nebraska and utilize the same support structure the E-4B uses. The E-4B is a 747 platform and is larger than the 767, but the E-4B is supported by only one hangar and four parking ramps at Offutt Air Force Base.
- The 787 is larger than both the E-3 and E-8 aircraft, and it has a wing span that is approximately 1.33 feet longer than the E-4B. The aircraft

should have no problem utilizing the existing E-4B facilities and runway infrastructure. An analysis of the hangar facility is recommended to ensure the 787 aircraft could utilize the existing E-4B hangar. The aircraft would definitely be too large for facilities that support smaller command and control aircraft, and these facilities would require modifications to support the much larger 787 aircraft.

b. Key Performance Parameters

Key Performance Parameters are critical requirements that must be met by potential replacement aircraft in order to be selected for a particular mission. The parameters identified in this research project correspond to commercial features since the authors have no insight on future Air Force specifications that may be required in the future. The parameters allow the three potential replacement aircraft to be compared to determine what, if any, aircraft have the potential to replace existing aircraft. The Key Performance Parameters identified in Table 10 identify the minimum requirements and, combined with Table 9, allow the formulation of a best selection from the three potential aircraft to replace the existing command and control fleet.

Key Performance Parameters						
Aircraft	767-400	737	787-8	E-4B	E-3	E-8C
Range must be 11 hours or greater un-refueled	✓	-	✓	✓	N/A	✓
Maximum takeoff weight must be at least 336,000 pounds in order to accommodate current and future command and control mission packages	✓	-	✓	✓	✓	✓
Cruise Speed must be commensurate with aircraft of its size and at least capable of Mach 0.70	✓	✓	✓	N/A	***	✓
Aircraft must be capable of having a service ceiling of at least 29,000 feet	✓	✓	✓	✓	✓	✓
A highly desired parameter is for the aircraft to be compatible with existing facilities	✓	✓	✓ *	✓	✓	✓
A highly desired parameter is for the platform chosen to be able to perform multiple missions utilizing the same common platform	✓	-	✓	-	-	-
Chosen platform should have a wide support structure available in the civilian market creating access to spare parts and logistical support	✓	✓	✓ **	-	-	-
Platform should utilize the latest technology and materials in a manner to increase fuel efficiency			✓			
*Aircraft larger than standard command and control aircraft and would be limited to facilities that can presently support the E-4B **Aircraft is expected to replace 767s in commercial airline fleets; aircraft is still being developed ***E-3 speed was limited for mission purposes (rotodome above aircraft) and not evaluated against other aircraft						

Table 10. Aircraft Key Performance Parameter Chart

The Key Performance Parameter chart (Figure 10) identifies that the Boeing 767 met all of the requirements except the use of the latest technology to increase fuel efficiency. The 767 is a mature platform that is more efficient than many aircraft available, but the Boeing has incorporated the use of composites and more fuel efficient engines that allow the 787 to claim a 20% greater fuel efficiency than aircraft in its class. The 787 meets all of the requirements stated for command and control missions. These requirements are only the commercial application specifications, and the aircraft would

require extensive modifications to make the aircraft capable of performing command and control missions. The existing aircraft do not meet all of the individual requirements, because they have separate missions that require different capabilities. The potential aircraft are required to accomplish all missions and make the aircraft selected become more of a multi-role aircraft than the aircraft that currently exist. This clarification is intended to clarify why some existing aircraft may seem to not meet all of the performance parameters identified.

E. CONCLUSION / RECOMMENDATION

This chapter analyzed the current Air Force command and control aircraft as well as potential commercial aircraft that could be converted into future military aircraft. The intent was to demonstrate that the Air Force will have to make a decision about their future command and control aircraft sooner rather than later. In order to replace the existing aircraft, potential replacement aircraft will have to have performance characteristics necessary to accomplish critical command and control missions. The decision to replace the current aircraft can not be based on cost comparisons alone. The operational needs will have to play a major factor in any decision concerning procuring new aircraft. In the difficult financial times the Air Force is facing, senior leaders may find it difficult to justify obligating money on new equipment in the anticipation of reduced future operations and support costs.

The recommendation in this section of the project identifies which aircraft should be procured as a likely replacement aircraft for the existing command and control missions. The aircraft currently accomplishing command and control missions were described in this section to identify the fundamental features and parameters required in a potential replacement aircraft for future missions. The replacement aircraft selected will be compared with other challenges, and a final recommendation for the overall MBA project is given in Chapter V stating which direction the Air Force should take.

The most likely candidate to replace the existing command and control aircraft is the Boeing 787. This aircraft satisfies all key performance parameters and is likely to be

the aircraft civilian airlines heavily rely on in the future. The 787 ability to fly 14.5 hours un-refueled will enable the Air Force to accomplish missions with less dependency on tanker aircraft support. The commercial version of the 787 does not have in-flight refueling capabilities. Other Boeing aircraft the Air Force operates have received the modification, and it should be a necessary modification for the 787 to also receive the critical capability.

The Boeing 737's major advantage in the comparison study includes its price and size. The aircraft's wingspan, length, and height are smaller or close to the same size as existing command and control aircraft. The 737 could utilize existing facilities without incurring any additional substantial costs. The Boeing 737 aircraft was also the cheapest aircraft analyzed, but after comparing key performance parameters, it was determined the aircraft could not satisfy the Air Force's need of having a range of at least 11 hours un-refueled. The Navy's P-8 will be equipped with in-flight refueling capabilities, but refueling every six hours compared to 11 hours (Boeing 767) or 14.5 hours (Boeing 787), make the aircraft a non-contender for future Air Force command and control missions.

Previously, the Air Force had planned to purchase Boeing 767 aircraft to begin recapitalizing the older KC-135 fleet. The plan had difficulty, but the 767 is being considered again as a future tanker aircraft. The Boeing 787 is \$2M cheaper than the 767, and it has major advantages compared to the 767 family of aircraft. While the 767 is capable of performing the mission, it is anticipated that the Air Force will not attempt to procure replacement command and control aircraft until new fighter and tanker aircraft are fully funded. Some new fighter aircraft are currently in production while others are still in the development stage. The future tanker aircraft has not been selected; however, the 767 is being considered as a tanker replacement aircraft. Many airlines have opted for the newer, Boeing 787, so if the 767 is not selected as the tanker aircraft, the 767 production line could be stopped. A second argument against choosing the 767 is that the 787 will be 20 percent more fuel efficient when compared to similar aircraft in the same class. The 787 is also composed of 50 percent composite material, which will significantly reduce corrosion maintenance by 30 percent, and regular scheduled maintenance costs will be reduced while possibly extending the aircraft's service life.

The Boeing 787's wingspan and length are longer than all command and control aircraft except the E-4B (747). If the 787 is chosen to replace existing aircraft, it is recommended the aircraft be based at Offutt Air Force Base, Nebraska, to utilize the support structure already in place. The Air Force will have to do further research to determine what additional cost will be incurred to construct additional facilities and modify runways if needed. Despite the additional money that will be required to support and sustain the Boeing 787 aircraft, it is the best alternative compared to the 767 and 737 aircraft.

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IV. CHALLENGES FACING THE AIR FORCE'S RECAPITALIZATION EFFORTS

Today's Air Force is faced with unique budget challenges unlike any other generation. In order to maintain and preserve their premier Air, Space, and Cyberspace dominance, the service must learn to adapt to a transforming political and socio-economical environment that presents unique fiscal and operational factors that affect the Air Force's ability to balance its assets and resources. Fiscal challenges encountered by the Air Force include but are not limited to the fact that the cost of maintaining personnel has steadily increased.

Over the last ten years alone, personnel costs have continued to increase due to increases in pay, benefits, and medical care. Costs continue to increase while the service has witnessed a steady decline in active duty personnel. From 1986 through fiscal year 2008, personnel cost will increase 57% while the end strength numbers would have decreased by 8% [53].

In conjunction with personnel costs, the cost to operate and maintain equipment is also on the rise. The cost of operating an aged and heavily used fleet has risen 179% since 1996. This has significantly hampered the Air Force's efforts to recapitalize its aging fleet. Through routine maintenance and replacing parts, older equipment is consuming additional money that could be used to purchase new equipment. If this trend continues, the service could find itself in a death spiral that could prove difficult and lengthy to recover from [53].

A crucial part of maintaining the current inventory is the ability to invest in modernization efforts that provide troops with equipment that enable them to perform the mission without having to worry about failure or breakages. As a percentage of total obligation authority, investment funding for modernization efforts has decreased 19% since 1986. This creates an additional challenge while the troops consistently do more with less while pushing equipment past their recommended operational limits [53]. In 1973, the average age of an aircraft used in the Vietnam War was nine years. Today, the average aircraft age has increased over 260% to 24 years. With an aging fleet of aircraft

that averages 24 years, the United States is slowly allowing other nations the opportunity to close the technological advantage gap once proudly maintained.

Whether it is concerning maintenance, spare parts, fuel, or downtime, aging aircraft consume more resources and will eventually impede the overall mission effectiveness [53]. Overall, these factors have a collective negative impact on readiness at every conceivable level in the military structure. Without adequate funds and support, troops cannot perform their mission effectively. In turn, this could have serious implications on the safety, well being, and morale of troops. An increased operations tempo coupled with operating a smaller and aged fleet negatively contributes to mission readiness, and the Air Force's state of readiness has declined 17% since 2001 [53].

A. COST / FUNDING PRIORITIES

Air Force senior leaders have been managing programs that have raised concerns in Congress. One program that has received attention is the E-4B Modification Block 1. These aircrafts date back to the early 1970's and have required extensive modifications to replace antiquated 1970s technology with state-of-the-art twenty-first century communication suites. The program to upgrade this epic platform was so enormous, that modification efforts encountered several problems including exceeding the cost and schedule.

Modifying existing aircraft may be less expensive than procuring newer aircraft in the short term, but in the long term it is generally more expensive. The aircraft may have compatibility issues with existing systems, and they may have problems performing missions with aircraft that have more modern equipment aboard. Similar to the E-4B example above, the modification process often experiences problems that will increase costs and delay the scheduled completion of the modification.

The Air Force has faced difficulties covering the cost of modernizing and purchasing aircraft. With the Air Force's existing dilemma, they may have less control of who performs certain missions. Due to the rising costs of GWOT, the budget has been

reduced and programs' funding cut. The Navy has funding in place for newer command and control aircraft to support their maritime missions.

Older aircraft are typically more expensive to operate and maintain than newer aircraft. An example of this is a comparison between the EC-135 and the E-6B aircraft. The EC-135 aircraft were older Boeing 707s used by the Air Force. The E-6 aircraft were newer Boeing 707s with larger, more fuel efficient engines. The Navy upgraded their TACAMO fleet from C-130 aircraft to the E-6 platform. The Air Force had predominantly performed command and control missions; however, the older, less efficient aircraft, were retired after the Secretary of Defense decided he wanted to have the mission performed by one platform. The Air Force's EC-135 aircraft were older and had increased operational costs compared to the Navy's newer E-6 aircraft.

One aircraft that was extensively modified successfully is the RC-135 aircraft. The RC-135 aircraft were re-engined at an estimated cost of \$700M for 21 total aircraft. The re-engining effort was expected to save approximately \$1.5B through the program to the year 2020 [52]. The E-3 and E-8 aircraft utilize the same Boeing 707 platform as the RC-135, and the estimated RC-135 engine modification costs can be used as a basis for determining the cost to replace the engines on additional aircraft. The fuel savings alone could be a strong determining factor to argue for engine replacement. With newer, more fuel efficient engines on the command and control aircraft, there would be a slightly lower need for tankers while the aircraft were flying. The RC-135 aircraft are able to fly four hours longer between refueling efforts with the newer engines, and their tanker support was reduced by at least 59 percent [52].

Command and control aircraft are mostly referred to as High-Demand Low-Density assets. The aircraft are relied on in nearly all contingencies around the globe. The aircraft's operators and maintainers often have to work longer to ensure the aircraft are mission capable for their critical requirements. As long as the aircraft are accomplishing their mission, the aircraft are not in the headlines. When aircraft have difficulty completing missions, the aircraft gain negative attention that requires the personnel to maintain and operate the aircraft better than they previously did.

Aircraft programs are currently and will always compete for scarce funds to improve performance capabilities. The command and control aircraft often take many years to develop, and once they are developed, they often require ongoing modifications to ensure the aircraft have the best technology available. The technology modifications may be difficult, and at times the aircraft may combine the use of high tech equipment with lesser capable equipment that may have compatibility issues.

All aircraft programs are important for their specific part of the mission. Fighter aircraft are required to attack enemies and protect friendly forces while tanker aircraft are essential to refuel tanker, cargo, bomber, fighter, and command control aircraft while operating. The Air Force has money prepared for new fighter aircraft, and they are preparing for the new tanker aircraft that is needed for the future conflicts the Air Force will be engaged in. The command and control aircraft are receiving modernizations, but no replacement aircraft is being developed at this time.

Command and Control aircraft are expensive aircraft to operate and maintain due to their complex systems that are required to keep them mission ready. The aircraft often have systems placed on them that are generally produced to perform tasks on the ground where electrical needs are stable. The systems often require additional upgrades to keep the systems compatible with the latest technology, and they also require highly trained technicians to maintain the aircraft. Aircraft crews are also a valuable asset. The pilots, navigators, mission crew, and others are responsible for ensuring the aircraft is operated correctly and the mission is accomplished.

B. SCHEDULE / PRODUCTION LEAD TIME

One challenge with modifying aircraft is having the aircraft completed on time to not interrupt operational requirements. The program office would have to work closely with the operational commanders to ensure the aircraft were modified at the appropriate time, but they would also have to work closely with the contractors to ensure the aircraft were completed on schedule.

Once the aircraft are modified, they will be more available for missions due to a decreased need for engine maintenance. The aircraft will still have to be serviced regularly, but the engines will require less maintenance between flights. The reduced maintenance need will also allow less personnel to maintain the aircraft. This is a strong advantage since the Air Force is continuing their downsizing efforts.

Mission Capable rates are a tool used to measure how often aircraft are ready to perform a mission. Older aircraft are often perceived as not being able to perform missions as well as newer aircraft. If an aircraft has a low mission capable rate, it is a signal that problems are ahead. Even after aircraft are modified, they may still experience a lower mission capable rate due to additional issues.

The noticeable feature that can improve aircraft performance is the engines. The E-3 and E-8 aircraft currently utilize TF-33 engines. Foreign command and control aircraft as well as Air Force RC-135 reconnaissance aircraft have upgraded to CFM-56 engines that provide increased reliability and more thrust. The CFM-56 engines burn approximately 20 percent less fuel than the TF-33 engines, and the TF-33 engines are more expensive and difficult to maintain [52]. New engines will not guarantee the aircraft will not have additional problems such as communication interfaces challenges or structural fatigue.

When the Air Force chooses to procure new aircraft, the production time must be taken into account. For example, the Boeing 787 is the latest, most fuel efficient Boeing aircraft of its size, but it has already been delayed six months from its initial delivery schedule. Currently, more than 500 customers have placed orders for the aircraft, and given the popularity of the aircraft, more orders can be expected. After the aircraft are produced, they have to undergo extensive communication and mission system upgrades to convert the aircraft from a standard passenger aircraft to an Air Force specific platform. The timeframe from when the Air Force decides to order an aircraft to the time it will be delivered must be included in any planning actions taken to ensure the mission can still be accomplished by existing aircraft until the newer aircraft are available.

C. PERSONNEL

The Air Force is currently reducing its force strength to recapitalize and modernize aircraft. Money is also being distributed to cyberspace systems used to fight the GWOT as well as for equipment across the entire combat spectrum. The Air Force's plan is to reduce the force structure from its 349,000 active duty airmen by 40,000 personnel. The savings are expected to be reutilized within the Air Force [54].

While the Air Force is reducing its force to pay for ongoing operations around the world, the Army and Marine Corps have been authorized to increase their force strength. Overall, the Secretary of Defense, Robert Gates, has authorized both services to increase in size over the next five years by a total of 92,000 people. The Army will increase by 65,000 while the Marine Corps will increase by 27,000. Currently, the Air Force has been completing its mission, reducing it personnel, and also filling Army in-lieu taskings. Despite the Air Force filling roles outside of their normal area of expertise with personnel assigned to critical career fields, senior civilian and military leadership has not announced any plans to increase the Air Force's end strength or reduce the dramatic personnel cuts presently taking place.

While the Air Force will be utilizing fewer personnel to accomplish increased missions, having to train on new aircraft could initially decrease the Air Force's ability to accomplish ongoing operations. The Air Force may have to take experienced personnel and train them on new aircraft while leaving less experienced personnel to accomplish critical missions with a high operational tempo.

If the Air Force proves to senior leaders and the other services it can continue operating on a reduced budget with less people, it may be preparing itself for an intense budget battle in the future. The ground forces are heavily involved in Iraq and Afghanistan, and they are presently receiving a lot of attention in the public defense sectors. For some, it may seem only correct for the Air Force to reduce its size and allow other forces to take over missions it used to perform. The Navy's Chief of Naval Operations, Admiral Michael G. Mullen, has been chosen to replace General Peter Pace as the next Chairman of the Joint Chief of Staff [55]. This could be an important move

that shows the plan of the Pentagon and the White House. With a Naval officer as head of the Joint Chiefs of Staff, the Navy may continue to operate and gain a larger role in some military operations around the globe. They may even be allowed to perform more missions that were strictly Air Force specific in the past. The Air Force must ensure they have the proper quantity and quality of personnel to ensure they can operate and maintain new aircraft that may be procured.

D. FACILITIES AND SUPPORT EQUIPMENT

The Air Force's decision to downsize could challenge its ability to bring new aircraft to the fleet. While downsizing, the Air Force has attempted to decrease the amount of money being obligated for personnel and facilities to accomplish ongoing operations. If the decision was made to procure new aircraft, existing facilities may have to be upgraded or new facilities built. New aircraft may also require new support equipment. The equipment would have to be available at home station as well as where the aircraft would operate from while deployed. This decision would increase overall costs and be a departure from the direction the Air Force is pursuing.

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V. CONCLUSIONS AND RECOMMENDATION

A. OVERVIEW

Command and Control aircraft require extensive funding to ensure they are readily available for missions. The aircraft require maintenance and modifications dollars to sustain their mission capable rates. Command and control aircraft programs require more funding no matter how the Air Force decides to accomplish the missions. More funding will be required to procure newer, more efficient aircraft, and additional funding would also be required to modernize existing aircraft. The total ownership costs needs to be evaluated to ensure the Air Force is allocating funds in the proper direction.

Aircraft that were highly effective during the Cold War are still being utilized today in a fight against different enemies. Some Air Force aircraft were designed for a long standoff and even a nuclear war between two superpowers. These aircraft are expensive to maintain and costly to operate. The size of aircraft is another detriment along with the low quantity of command and control aircraft available for the various locations the Air Force and allied nations are operating in today. The current situation seems to indicate the United States military will be heavily employed for years to come. The Air Force is facing dilemmas that, if dealt with now, will reduce future strains and eliminate problems that could occur. The Air Force has multiple choices to ensure they are able and capable of performing current and future missions; however, budget reductions and increasing requirements have placed a strain on equipment and personnel.

The focus of this research project was to address problems facing the Air Force's command and control fleet and identify ways to correct deficiencies. The command and control aircraft often receive less priority than fighter or tanker aircraft, but the aircraft perform an important role that would negate the need for fighter and tanker aircraft if they were not available.

The project was able to make comparisons between the United States Air Force and Navy and also between the United States Air Force and the Japanese Defense Force. There were no case studies on the topic available, so research was gained from valuable

sources and analyzed for relevancy to the points being addressed. The challenges are not going to depart the United States military any time soon due to ongoing requirements and decreased budgets. The research conclusions should provide a “way-ahead” for the Air Force and for other services that are in similar situations with an aging aircraft fleet.

B. CONCLUSIONS

Air Force leadership must develop a consistent path to accomplish current and future missions. With more aircraft and personnel usage required, the Air Force must implement decisive actions to remain a credible military service and prevent adverse consequences from occurring. There are multiple scenarios that could arise from the Air Force not being able to accomplish command and control missions due to aging aircraft. Some possible outcomes are: 1) Loss of funding; 2) Air Force senior leaders losing rapport with Congress; and 3) Air Force having less control of strategic command and control aircraft missions.

The Air Force is currently reducing personnel and retiring aircraft in an effort to provide money for aircraft procurement and operations. As the Air Force reduces aircraft, it can lose funds that were committed for the aircraft. For example, when the Air Force transferred the Looking Glass mission to the Navy, they lost funding for the aircraft while the Navy received additional funds to perform the mission. The Navy’s decision to upgrade their fleet prepared them to perform the Looking Glass mission more effectively and efficiently while the Air Force kept older aircraft that had continuous communications upgrades.

Air Force senior leaders may lose rapport with Congressional members if they don’t convey a structured plan to carry the service through difficult times. The Air Force has planned to retire aircraft and eliminate personnel, but Congress has questioned if these are proper actions to take for the situation. The E-4B was slated to retire, but it is now included in the fiscal year 2008 Presidential budget. Initially, the Air Force had

planned to use the money from retiring the E-4B to procure C-32A aircraft for a different mission. Congress can make it difficult for Air Force leaders to make their changes if they lose confidence in senior leadership.

The Air Force has been the dominant service for airpower requirements and has taken the lead on procuring aircraft for other services in the past. The Navy has shown they can effectively manage command and control aircraft similar to the Air Force and even demonstrated a more effective approach to accomplishing the mission. If other branches develop strong aviation programs, the Air Force may not be as dominant and have less authority in aircraft matters. When the airborne command post mission was transferred to the Navy, it marked the first time the role became a joint mission instead of Air Force supported. DoD may benefit from the Navy performing the mission, but Air Force aviation may be losing ground to other services. Research concluded that the Air Force has two avenues to pursue. They can purchase new Boeing 787 aircraft or modify existing aircraft currently in the Air Force fleet. The following section provides details on the two conclusions identified in order to make a final recommendation.

1. Purchase Boeing 787 Aircraft

Command and Control aircraft are mostly referred to as High-Demand Low-Density assets. The aircraft are relied on in nearly all contingencies around the globe. The aircraft's operators and maintainers often have to work longer to ensure the aircraft are mission capable for their critical requirements. As long as the aircraft are accomplishing their mission, the aircraft are not in the headlines. When aircraft have difficulty completing missions, the aircraft gain negative attention that requires the personnel to maintain and operate the aircraft better than they previously did.

Aircraft programs are currently and will always compete for scarce funds to improve performance capabilities. The command and control aircraft often take many years to develop, and once they are developed, they often require ongoing modifications to ensure the aircraft have the best technology available. The technology modifications

may be difficult, and at times the aircraft may combine the use of high tech equipment with lesser capable equipment that may have compatibility issues.

The Boeing 787 aircraft is an aircraft that is expected to become the backbone of major airlines similar to how the Boeing 707 was historically. The aircraft is expected to have significant operational savings since the aircraft is lighter and using more composites than any other aircraft available on the market today. With a future global support structure in place, the Air Force should follow suite to the airlines and use the aircraft for its command and control missions.

Boeing's 787 aircraft has rewritten the rule book on how a commercial aircraft is designed and manufactured. Although the project is nearing the end of the production cycle, Boeing must negotiate some unforeseen hurdles. Once those delays are cured, the aircraft should enter the testing and certification phase with the first buyer, All Nippon Airways. If the 787 platform lives up to all its reported hype and expectation, the platform should seriously be considered for military application.

The features and characteristics of the 787 make it a viable candidate for Air Force missions. The 787 has a range of 14.5 hours before requiring fuel, a maximum takeoff weight of 484,000 pounds, and an operating ceiling of 43,000 feet. For a service operating platforms with an average age of 25 years, the three variants of 787s should be considered as replacements for various mission roles. Whether it's ferrying senior leadership, accomplishing command and control missions, or performing specialized missions, the 787 variants may prove to be a viable option for future recapitalization investments.

2. Modify Existing Command and Control Aircraft

Command and Control aircraft are expensive aircraft to operate and maintain due to their complex systems that are required to keep them mission ready. The aircraft often have systems placed on them that are generally produced to perform tasks on the ground where electrical needs are stable. The systems often require additional upgrades to keep

the systems compatible with the latest technology, and they also require highly trained personnel to operate and maintain the aircraft.

The option to modify existing aircraft would require less money than procuring new aircraft. The aircraft could also utilize previously experienced and trained personnel to continue to operate and maintain them. This would aid in keeping the costs to the lowest possible level.

C. RECOMMENDATION

The Air Force must develop a roadmap for the future. They must assess the needs of its strategic aircraft and place a value on the future use of the aircraft. The aircraft may be of great importance in the event of another terrorist attack or major natural disaster. Funding programs are major concerns; however the Air Force must properly analyze its mission needs and decide what capability they want to have for our national defense.

No previous information was discovered on this research topic in particular, and no one has combined the various information reflecting implications the Air Force will have by removing itself from strategic aircraft roles. This document should be used as a starting point for future research to expound upon the current information and search for other trends and issues relating to the topic. More information concerning the future uses of the command and control aircraft, world situation, and the Air Force budgetary issues could be researched further in-depth and analyzed to discover additional problems facing the Air Force to prevent future mistakes from being made.

The Air Force's dilemma is whether to procure new aircraft or continue modifying existing aircraft for command and control missions. The upgrade costs may be less than procuring new aircraft; however, the total maintenance, operation, and modification costs must be compared to determine the true cost of the aircraft. No matter what direction the Air Force decides to take, they must provide the extensive funding required in support of the various command and control mission and requirements. The overall project recommendation is below.

The Air Force possesses existing command and control aircraft that have been continuously modified to keep the aircraft effective in today's environment. Given the current budget shortages for aircraft programs, the Air Force should continue modifications on existing aircraft and continue flying the aircraft until money for aircraft procurement becomes available. The existing command and control aircraft platforms are proven, and the maintainers and operators are trained on the systems. Modifying existing aircraft can be less expensive than procuring new aircraft with the newer systems already installed; however cost cannot be the only determining factor when deciding to modify existing aircraft or procure new aircraft. Questions that must be researched are how long will the modification keep the aircraft mission capable, and can the modification effectively allow the aircraft to perform its mission?

When aircraft are modified, the systems do not renew the aircraft's structural life. Aircraft that have structural fatigue or a high amount of flying hours on them may require continued repair and inspections to keep the aircraft flying. One example is the EC-135 aircraft that required extensive modifications to keep the communication systems operating properly. Existing aircraft may be utilized if the aircraft can be modified and perform the mission efficiently. Many military people do not drive an automobile that is twenty years old across country, but our military places personnel in aircraft to perform missions around the globe that may be over thirty years old.

Aging aircraft eventually cost more to maintain and operate, become increasingly more difficult to repair, and experience more down time for maintenance than newer aircraft that possess the latest technology available. The Air Force has the option of purchasing newer aircraft to replace the existing aircraft currently performing command and control missions; however with the fiscal constraints and competing programs, the best alternative is to continue modifying the older aircraft. The additional modifications should keep the aircraft mission capable until an additional analysis can be conducted on future aircraft that could be utilized. The time extension will also allow time for the Air Force to provide adequate funding for command and control procurement programs.

D. ADDITIONAL RESEARCH QUESTIONS

Research was constrained due to the lack of information available. Many command and control aircraft were highly classified during the Cold War, and the information is still not readily available today. Additional questions that will assist the senior leaders' decision making process for command and control aircraft include:

- 1) What will be the Air Force end strength when force reductions are completed?
- 2) How long will the GWOT last, and how will it change the future requirements for command and control aircraft?
- 3) What products will become available in the future to reduce the procurement costs of command and control modifications?

E. AREAS FOR FURTHER RESEARCH

This research attempted to document and uncover how the Air Force could effectively perform its command and control missions. The researchers placed major emphasis on manned aircraft and are aware that attention could also be given to unmanned command and control missions. The unmanned aerial vehicles are gaining additional roles and may be used as command and control platforms as well. Further research could be performed to determine the overall operational and cost savings of using unmanned aerial vehicles.

An additional area that needs to be researched is a cost benefit analysis of the new tanker aircraft selected to determine if the platform would be a suitable replacement for the aircraft that were recommended to be modified. Currently, the Boeing 767 is a contender to replace the existing KC-135 tanker aircraft. When more information concerning the selection is available, it should be analyzed to determine if command and control aircraft could be added to the contract to receive substantial discounts on the aircraft by using the Air Force tanker contract. Due to the limited information currently available, the possibility of using the future tanker aircraft as a command and control

aircraft could not be researched at this time; however, the aircraft must be analyzed in the future to determine its feasibility for command and control missions.

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