Defense Science Board
Task Force Report

on

AERIAL REFUELING REQUIREMENTS

May 2004

Office of the Under Secretary of Defense
For Acquisition, Technology, and Logistics
Washington, D.C. 20301-3140

OFFICE OF THE SECRETARY OF DEFENSE
3140 DEFENSE PENTAGON
WASHINGTON, DC 20301-3140

DEFENSE SCIENCE BOARD

MEMORANDUM FOR THE ACTING UNDER SECRETARY OF DEFENSE (ACQUISITION TECHNOLOGY AND LOGISTICS)

SUBJECT: Report of the Defense Science Board Task Force Report on Aerial Refueling Requirements

I am pleased to forward the final report of the DSB Task Force on Aerial Refueling Requirements. The report evaluates current aerial refueling capability and future DoD aerial refueling requirements. The Task Force examined the current state of the USAF tanker fleet, the corrosion and maintenance issues associated with it, the studies pertaining to the KC-135, and several near-term options that the DoD has with regard to recapitalizing the fleet.

The study concludes that the tanker fleet is critical to the U.S. ability to project power. Even though the current fleet is aging, corrosion can be controlled. Maintenance cost growth appears to be slowing to a more manageable rate. Even though the future requirement of tankers is uncertain at this time, embarking on a major recapitalization of the fleet should await completion of studies that will provide insight into the future requirements. The recapitalization choices should address both new tanker aircraft and conversion of used commercial aircraft.

I endorse all of the recommendations of the Task Force and encourage you to review the report.

Vincent Vitto

Vince Vitto
Vice Chairman

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DEFENSE SCIENCE
BOARD

MEMORANDUM FOR THE CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Report of the Defense Science Board Task Force on Aerial Refueling Requirements

The U.S. Air Force Tanker Force is an essential element of the ability of the United States to project power. This critical support mission also allows the United States military the reach and flexibility it needs to maintain global presence.

The Defense Science Board Task Force on Aerial Refueling Requirements reviewed current and future needs for the aerial refueling mission. In addition, the Task Force examined a variety of options with respect to recapitalizing the tanker fleet.

Specifically, the Task Force assessed issues pertaining to the KC-135. The Task Force asked the following questions:

- Are the age of and corrosion problems with the KC-135 fleet sufficiently severe to change the recapitalization dynamics for the fleet? By examining the fatigue life of the airframe and the problem of corrosion in this aging aircraft, the Task Force sought to understand the level of field and depot maintenance requirements to sustain the KC-135 fleet. Additionally, projected costs associated with corrosion were reviewed to clarify whether or not corrosion control costs were becoming unmanageable.
- How many KC-135 replacement tankers are needed? To understand the required capability, the Task Force reviewed studies and reports on the matter and reviewed the tasking of tanker aircraft during Operation Iraqi Freedom
- What makes sense for near-term steps? The Task Force made recommendations on near-term steps based on the findings from the previous two questions.

The Task Force did not find compelling material or financial reason to initiate a replacement program prior to the completion of an upcoming study of future mission capability needs and an Analysis of Alternatives. Corrosion can be controlled and the growth of operation and support costs is not as large as once projected. At present, the total future requirement for KC-135 tanker replacements is uncertain (but clearly in the hundreds of airframes). The Task Force expects the upcoming studies to answer this question so that a major tanker recapitalization program can be undertaken with an adequate basis for decision-making.

The Task Force examined a few of the near-term options that are possibilities if the Department is compelled to do something prior to embarking on a major tanker recapitalization program. In particular, the Task Force reviewed refurbishing used commercial DC-10s.

On behalf of the Task Force members, I express my appreciation for the effort and contributions of the government advisors; presenters from the government and industry; Col William Story, USAF, Task Force Executive Secretary; and Lt Col David Robertson, USAF from the DSB Secretariat.

Donald Pilling

ADM Donald Pilling, USN (Ret.)
Chairman

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EXECUTIVE SUMMARY

Aerial refueling capabilities are an essential enabler of U.S. power projection and other critical national missions. OPERATIONs ENDURING and IRAQI FREEDOM (OEF and OIF) could not have happened without these aerial refueling capabilities. Aerial refueling makes possible rapid deployment of forces to contingencies and the elective employment of those forces in the contingencies. In OIF there were over 8500 aerial refueling sorties flown and about 450 million pounds of fuel offloaded. In addition, aerial refueling remains a critical element in supporting the bomber leg of U.S. nuclear forces and other special national security missions.

The task force was charged to evaluate current aerial refueling capability and to identify and evaluate alternative means of meeting future aerial refueling requirements.

CURRENT SITUATION

The bulk of U.S. air refueling capabilities reside in the USAF's fleet of tankers. This fleet includes 541 KC-135s and 59 of the larger KC-10s, which have about twice the refueling capacity of the KC-135s. More than half of the KC-135 fleet is assigned to Air National Guard and Reserve units.

The U.S. Navy and Marine Corps also possess aerial refueling capabilities with F/A-18 E/F, S-3B, and KC-130 aircraft. While delivering only a small fraction of the fuel unloaded in the major combat phase of OIF (less than 5 percent of the total), these Navy and Marine Corps assets played an important role in supporting tactical aircraft employment.

The KC-135 portion of Air Force's tanker fleet (90 percent of the total number of tankers) is the oldest in the inventory. A total of 732 KC-135 airframes (a Boeing 707 variant) was built and procured at a rate of 75 to 100 per year during the late 1950s and early 1960s. These aircraft were not built with longevity as a key acquisition objective. The average age of the remaining 541 KC-135s today is over 44 years.

There are two basic versions today — KC-135E and KC-135R — both upgrades from the original KC-135As. The 417 KC-135R models have been refitted with more modern engines, provide about 20 percent greater refueling capacity, and have a slightly lower average age than the 124 KC-135E models. The plan is to retire 61 of the 124 older E models over the next three years and reallocate the crews to the remaining KC-135s, enabling a higher crew to aircraft ratio for the remaining aircraft and thus greater availability per aircraft. These retirements will reduce the KC-135 fleet by 10 percent.

The useful life of an aircraft (or fleet of aircraft) depends on the effects of usage and the environment, as well as the costs of maintaining mission readiness.

Usage, which induces material fatigue, is not the driving problem. Total flying hours are relatively low for the KC-135s: the current airframe average is about 17,000 hours. Fatigue life is estimated to be 36,000 hours for the E, 39,000 hours for the R. Cycles are commensurately low on average (3800 for the R and 4500 for the E). Thus, the airframes should be capable to the year 2040 based on current usage rates.

Effects of airframe aging are a greater concern. These effects include corrosion and other environmental causes of material degradation. The struts that attach the engine to the wings of the KC-135E models are a prime example of the problems of aging and environment. The struts are near the end of their service life due to exposure to high temperatures and corrosive environments and, assuming the KC-135Es are not retired, a major structural repair to the KC-135E struts is planned for initiation in FY06.

Annual maintenance costs have increased substantially from 15 years ago but have recently leveled off. The total annual operation and support (O&S) for maintaining the KC-135 fleet is about $2.2 billion. Programmed depot maintenance (PDM) rose sharply in the early 1990s to about 25,000 hours per year. It peaked again in the late 1990s to almost 35,000 hours — due largely to a major cockpit avionics modernization — but then dropped to about 28,000 for the past few years. The recent increases in depot hourly rates (versus hours) are due to several reasons, including corrections for under-pricing depot hours in the late 1990s. The number of KC- 135 aircraft in PDM over this period went from 59 to a peak of 187 in 1997 and the number is now running at about 80. Estimates of future O&S cost trends range from an increase of 1 percent (the USAF 2001 *Extended Service Life Study*) to 6.5 percent (the USAF 2003 *Business Case Analysis*) per year. Examination of hours and hourly cost projections on more recent data than was used in the *Business Case Analysis* suggest that the annual rate of growth is much less than projected in 2003.

The task force did not find evidence that corrosion poses an imminent catastrophic threat to the KC-135 fleet mission readiness.

The task force did find evidence of a maintenance regime well poised to deal with corrosion and other aging problems. The regime includes a field-level maintenance and inspection program comprised of an annual inspection involving more than 1300 man-hours complemented by more frequent corrosion prevention and detection routines and other safety related inspections. The maintenance regime also includes a 60-month cycle (shorter for aircraft permanently stationed in corrosive environments) programmed depot maintenance program. The Air Force has been very successful in reducing the time that aircraft are in maintenance — from 440 to 210 days — through some innovative production line modifications and improved procedures. Further, the number of major structural repairs in depot appears to be decreasing.

Solutions are in hand to deal with the known problems with the fleet, including the KC-135E engine strut. The task force suggests that there may be other modifications to maintenance and deployment practices, which could have a significant effect on further controlling corrosion. One example is to change the aircraft deployment rotation practice so that an aircraft is exposed to the most corrosive deployment environment immediately after it has undergone depot maintenance and is least susceptible to corrosion. Another example is to explore possibilities of low-cost sheltering of aircraft, as recent studies have indicated the significant effect of sheltering on reducing corrosion rates. There also may be a difference between Navy and Air Force field corrosion control practices, which should be examined.

However, there is a recapitalization challenge that cannot be deferred indefinitely. There are risks in continuing to delay recapitalization. Even if tanker replacement at a rate of 15 per year began now, there will be 80-year-old KC-135 aircraft in the fleet awaiting replacement if the entire KC-135 fleet is to be replaced by a like number of similar capacity aircraft.

FUTURE NEEDS

The major driver for future aerial refueling needs is the number and type of nearly simultaneous "major" operations. Demands on aerial refueling are particularly stressed when time is of the essence for the mission and when local infrastructure is immature**.** There are a myriad of other factors that have second order effects on fleet characteristics including capabilities to operate on short runways, to refuel multiple aircraft simultaneously, to receive as well as offload fuel, and to refuel unmanned platforms.

The scenario based Tanker Requirements Study 2005 (TRS-05) found that a fleet of 500-600 aircraft (KC-135R equivalent) and an increased crew-to-aircraft ratio would be needed to support the Strategic Integrated Operations Plan (SIOP) missions and one major theater war (MTW). The study, completed in early 2001 but never officially approved, examined the sensitivity of fleet size to number and type of nearly simultaneous missions. However, the study did not explore how these missions might change in the future. It has not been updated to reflect the transition from a two MTW sizing strategy to a 1-4-2-1 strategy.[1]

[1] The definition of 1-4-2-1 is: 1- Defend the United States and Territories, 4- Deter forward in four critical regions, 2- Swiftly defeat the effort in overlapping major conflicts, 1- Upon the President's direction, win decisively one of the conflicts.

The 500 – 600 fleet size finding is the size of the current fleet and is not inconsistent with OIF experience. The number of tanker aircraft supporting OIF directly and indirectly peaked at 319 — out of 379 fully mission capable aircraft available — with 182 of these tankers forward deployed to U.S. Central Command Air Forces (CENTAF). While there were other fully mission capable aircraft not in depot maintenance that could have been made available, one can envision major theater campaigns of greater scale and intensity than OIF. The task force did not examine if OIF could have been supported with fewer tankers.

There are new missions, new modes of operations and changing operational situations that could increase or decrease the demand for, and nature of, aerial refueling. One is homeland defense, in which a sizeable number of interceptor aircraft may need to be airborne over major cities for extended periods. Over 100 KC-135 equivalent tankers could be needed for this mission, depending on the number of cities and patrol aircraft aloft. Alternative concepts of operations could significantly reduce this number. The shedding of organic firepower by U.S. ground forces and concomitant increased dependence on responsive firepower delivered from loitering attack aircraft is another source of increased demand for aerial refueling. Two other possibilities are more U.S. reliance on sea-based operations over long distances, and a transition to smaller but more flexible tactical tankers in-theater, which may be in order to avoid large concentrations of KC-135 and KC-10 tankers at a few airbases. Further, if the remaining B-52s are reengined, the fuel savings could substantially reduce strategic force demands on tanker assets. The impact of leveraging the F/A-22 and F-35 to require only a single tanking on either mission ingress or egress as a standard employment concept could be significant.

The task force did not find a comprehensive up-to-date study of future aerial refueling needs that takes into account evolving planning assumptions (e.g., 1-4-2-1) and new modes of warfare. However, the task force believes there is time to conduct such a study before embarking on a major tanker replacement program. The DoD is currently planning a new Mobility Capabilities Study with results expected in Spring 2005, which should provide insights in this area.

WHAT TO DO

The task force has concluded that with manageable growth in KC-135 operating and support (O&S) costs and in the absence of evidence of imminent fleet-wide catastrophic failure and with evidence of a sound corrosion control program, which may be further improved, the DoD can defer major recapitalization investments at least until the Analysis of Alternatives (AoA) directed by AT&L and the Mobility Capability Study (MCS) is complete in mid- 2005. There are unknowns but no greater than exist for the planning of other elements of the future force. If it were possible to accelerate the tanker AoA and MCS for completion by the fall of 2004, this would minimize risk and maintain the entire set of options currently available. A fall 2004 completion date would allow sufficient time to provide input into the budget process. In addition, a decision in the fall may minimize disruption to the Boeing 767 production line as it nears the end of its run. If DoD believes that 767 is a viable tanker aircraft candidate, then it should consider negotiating a "smart shutdown" of the 767 production line.

The DoD must continue — and expand if necessary — aggressive maintenance and corrosion control programs for the tanker fleet regardless of near-term decisions on recapitalization. There may be demands on the tanker fleet that exceed those of OIF before any new aircraft could enter the fleet.

The task force concurs with the plan to retire 61 KC-135E models. It would release crews and spares that could be reassigned to the remaining aircraft. These actions would enable the DoD to enhance both aircraft and aircrew availability, thereby producing higher peak sortie rates and mitigating the 10 percent reduction in number of KC-135 aircraft. The Air Force and U.S. Transportation Command (TRANSCOM) were comfortable with their ability to meet current demands with this reduced fleet size. Actions that could mitigate any loss in near term capability from the retirement of the remaining KC-135Es range from exercising the current lease/buy arrangement for the KC-767 tankers to converting used commercial aircraft. It should be noted that the task force did not examine the advantages and/or disadvantages of lease/buy arrangements.

A tanker fleet consisting of at least two different types of aircraft is likely to be the most cost-effective hedge against a massive, unanticipated problem grounding a fleet of a single airframe type. Furthermore, some missions are dependent on large numbers of tanker aircraft (for example, when refueling is widely dispersed in area but compressed in time); whereas other missions could be more efficiently served by fewer, larger capacity aircraft, such as strategic bomber missions. A mix of large tankers for strategic and deployment missions and smaller, tactical tankers for employment missions may be appropriate.

The task force recommends serious consideration be given to:

- **Purchasing and converting used aircraft for aerial refueling**. The task force focused on one option: converting some number of available DC-10-30s to KC-10s. A recent conversion of two DC-10s to KDC-10s for the Netherlands was completed at a cost of $45 million per aircraft. Future recapitalization could also involve the conversion of other types of used aircraft as they become available on the market.
- **Re-engining some KC-135Es** —if it is deemed necessary to offset the near-term loss in capability from the programmed KC-135E retirements.
- **Arranging for contractors to provide some of the aerial refueling needs** — especially applicable, but not limited to the homeland defense mission. The Navy currently uses a commercial 707 rigged for drogue refueling. This aircraft is operated by the Omega Aerial Refueling Services, Inc., which has expressed interest in purchasing retired KC-135Es so it could offer this service for Air Force aircraft as well. The United Kingdom is also studying this

concept and their experience could provide insight into the viability of a large scale lease of refueling capability.

- **Working with manufacturers of large airframes to determine the potential to configure new generation commercial aircraft for the aerial refueling role. It is important not to preclude future opportunities with new generation aircraft that might be lost through a near-term commitment to major recapitalization.** An additional aspect of developing a new aircraft would be the avoidance of a parts obsolescence problem in the far term. Obtaining an aircraft nearing the end of its production run, coupled with very low procurement rates and an expected service life of several decades, there is a good possibility that repair parts and infrastructure will become scarce and exceedingly expensive in the latter stages of a prolonged procurement and operation of the aircraft. This problem is not unique to aircraft. Assuming a commercial market is developed for the new aircraft, the repair and spare parts would be amortized over an increasing production base rather than a small/government-only production base.

CHAPTER 1. INTRODUCTION

Aerial refueling capabilities are an essential enabler of U.S. power projection and other critical national missions. Initially procured exclusively as tanker aircraft for the nuclear strike force, tanker involvement in Southeast Asia from 1964 through 1973 brought changes to the tanker mission set. Today, Operations ENDURING and IRAQI FREEDOM (OEF and OIF) could not have happened without these aerial refueling capabilities.

As this capability remains vital to DoD missions, evaluation of options to sustain and/or to recapitalize the aerial refueling fleet is important to determine how best to maintain this capability without jeopardizing other major acquisition programs. The convergence of several acquisition programs constrains tanker acquisition to ten to twenty aircraft per year. The low recapitalization rate implies an extended period of time, measured in decades, to replace the existing inventory.

SCOPE

At the request of the Deputy Secretary of Defense, the Defense Science Board (DSB) formed a task force to evaluate current aerial refueling capabilities and future DoD aerial refueling requirements. Specifically, the task force was asked to address the following areas with respect to DoD aerial refueling capability:[2]

- Retaining the requisite number of assets to maintain capability
- Performing a service life extension on the requisite number of existing aircraft
- Acquiring new refueling capabilities

[2] The complete terms of reference for the Defense Science Board Task Force on Aerial Refueling Requirements is in Appendix I. Appendix II lists the task force members. Appendix III provides a list of briefings presented to the task force.

- Evaluating other methods to address refueling needs

Study Approach

The aerial refueling capability is critical to DoD operations across the spectrum of its missions and this capability is expected to remain critical to future DoD missions. In order to plan to meet the needs of aerial refueling, the past, present, and possible future requirements on aerial refueling tankers must be well understood. The analysis that follows reviews the background of the tanker fleet, examines the current status of and costs associated with aerial refueling capabilities, in particular the KC-135, and reviews the future needs of the tanker. In conclusion, recommendations are offered to assist the DoD in planning for tanker recapitalization.

TANKER BACKGROUND

The bulk of U.S. aerial refueling capabilities reside in the USAF's fleet of tankers. This fleet includes 541 KC-135s and 59 of the larger KC-10s, which have approximately twice the refueling capabilities of the KC-135s. These assets can perform secondary missions of passenger and cargo transport, as well as aeromedical evacuation. In the future, they also can be equipped to serve as communication relays, a mission that may rival in importance the refueling mission. More than half of the KC-135s are assigned to the Air National Guard and Air Reserve, whereas all of the KC-10s are operated by the active duty Air Force.

The KC-135 portion of the Air Force's tanker fleet is the oldest in the inventory. The Air Force procured 732 KC-135A aircraft between 1954 and 1965, with a delivery rate of 75 to 100 aircraft per year. The aircraft is a slightly larger airframe than Boeing's 367-80 aircraft, the prototype for Boeing's commercial 707 aircraft. In the mid-1950s, the Strategic Air Command needed a jet-powered tanker to replace the propeller-driven KC-97 and the KC-135 design was fielded as an "interim" jet tanker. Unit costs ranged from $2 million to $4 million per aircraft after the initial lot of 29 aircraft, which cost $8.7 million per copy.

These aircraft were not built with longevity as a key acquisition objective, unlike the similarly aged B-52, which had special care taken in production to ensure an extended life. The average age of the remaining 541 KC-135s is over 44 years today, with a narrow spread around the average: the oldest aircraft is 47, the youngest is 38.

There are two basic versions of the aircraft today — the KC-135E and the KC-135R, which are both upgrades from the original KC-135As. The original upgrade of the KC-135A to the KC-135E added engine struts (pylons) and refurbished P&W JT3D engines from retired 707 aircraft. Those retired 707 aircraft averaged 20,000 to 40,000 hours of flight at that point. Later, a second major upgrade of KC-135s, some KC-135Es and some KC-135As, were given new CFM 56 engines (and new struts and pylons), which resulted in better fuel efficiency and less noise. These aircraft were relabeled KC-135Rs. The R's greater efficiency means that a KC-135E is about .8 of a KC-135R in fuel offload capability.

The useful life of an aircraft is a function of the effects of usage (e.g., flight hours and cycles, which are the number of takeoffs and landings), the environment in which they must operate, and the investment in maintenance to sustain mission readiness. Usage, which drives material fatigue, is not a problem for these aircraft. Current airframe hours average 17,000. Boeing analysis indicates that the KC-135E airframe has a fatigue life of 36,000 hours, and a KC-135R airframe has a fatigue life of 39,000 hours. As a result, at historical usage rates, these airframes should not approach their fatigue lives prior to 2040.

Effects of aging are a greater concern. These effects include corrosion and other environmental causes of material degradation. A prime example is the KC-135E engine struts, which were obtained from retired 707 and 720 airframes. Because of their exposure to engine heat, severe heat-induced corrosion and fatigue have occurred. The Oklahoma City Air Logistics Center at Tinker Air Force Base depot has developed an "interim" strut repair for about

$100 thousand per strut, awaiting the FY06 program initiation of a fully reworked strut repair with a cost of about $1 million per strut.

It is this Air Force concern with the age of the aircraft and potential corrosion affecting the useful life of the airframe, and the financial and operational consequences of block obsolescence, which led to an acceleration of Air Force plans to recapitalize the KC-135 portion of the tanker force, rather than wait until the beginning of the next decade. It is this combination of factors and needs that drove the initiation of this study.

CHAPTER 2. KC-135 AGING, CORROSION, AND DEPOT COSTS

KC-135 AGING

KC-135 aircraft were among the first generation of turbojet airplanes (707s, DC-8s, etc.), and have experienced significant corrosion issues. These issues are directly attributable to what are viewed today as inferior corrosion resistant metal alloys and inferior corrosion prevention applications used in construction and early maintenance, as well as to inadequate corrosion prevention programs during the initial years of service. In current briefings and the *KC-135E Business Case Analysis* (BCA), the Air Force postulates these aircraft will experience significant cost growth for corrosion-related maintenance and are susceptible to a potential fleet-wide grounding due to a surprise finding related to age or material condition. The task force reviewed the aging, corrosion, cost, and reliability issues with several expert sources, including Air Force maintenance management and aerospace structures analysts and academics.

Despite the aircraft's already lengthy time in service, the fatigue life of the aircraft is not a driving concern. As noted in Chapter 1, current airframes average well below the estimated fatigue life of 36,000–39,000 hours and based on current annual flying hours, the airframe fatigue life will last until approximately 2040. Aircraft cycles, which are takeoffs and landings, are also a critical factor affecting service life. The relatively few cycles experienced by these aircraft, about 250 annually, portend an unusually long service life.[3] These factors make the effects of aging, primarily with respect to corrosion, the critical determinant in service life.

3 Current average cycles are 3818 for the R model and 4464 for the E model, with a tight distribution around the mean.

KC-135 CORROSION

The task force did not find corrosion to be a forcing function for a decision to replace the aircraft at this time. Corrosion on the KC-135 fleet appears to be a challenging, yet manageable issue. This finding is consistent with the *KC-135 Economic Service Life Study* (ESLS). It is supported by task force observations and briefings at the Oklahoma City Air Logistics Center (ALC)[4] and further supported by commercial operators, Department of the Navy briefings, and the professional judgment of aerospace structures experts who were contacted.

The Air Force has clearly demonstrated the ability to successfully address the impact of corrosion on the aircraft. The maintenance regime includes a 60-month programmed depot maintenance (PDM) cycle (shorter for aircraft permanently stationed in a corrosive environment), which includes aggressive discovery and treatment of corrosion. Air Force data shows that major structural repairs (MSRs) on the KC-135s in PDM have remained relatively constant, showing a slight decreasing trend since the mid-1990s. Significantly, as the Air Force continues to address corrosion problems on the aircraft, they are performing maintenance with state of the art corrosion resistant replacement parts, finishes, coatings, sealants, and lubricants. As repairs have been completed over the past two decades through several depot maintenance periods, the fleet now demonstrates improved resistance to corrosion in repaired areas consistent with the corrosive resistant behavior of newer generation turbojet aircraft.

The Air Force also maintains a rigorous corrosion prevention regime in its field maintenance activities. Field units conduct annual periodic inspections involving more than 1300 man-hours per aircraft that include structural inspections for corrosion. The periodic program is complemented by more frequent corrosion prevention and detection routines and other safety-related inspections. These include pre-flight inspection, hourly post flight inspections at 60-day

[4] The task force visited the Oklahoma City ALC, which performs depot-level maintenance on the aircraft, to talk with engineers and management assigned to the KC-135 program and to examine aircraft undergoing depot maintenance.

intervals, and critical corrosion inspections (minor at 180 days and major at 360 days), plus an established wash and lube requirement at 120-day intervals. In addition, there is an aircraft basing rotation scheme, wherein aircraft are assigned to severe corrosion zones once in a PDM cycle.

Because of the extraordinarily low utilization rates of these aircraft, once corrosion is effectively managed at an acceptable cost, there is no compelling rationale for retiring the airframes for reasons related to material condition. Data presented at the Oklahoma City ALC showed that, although costs grew in the late 1990s, PDM hours for heavy structural maintenance and one-time structural repairs experienced only slight increases. Heavy structural repair hours grew slightly in the late 1990s and then contracted after 2001. One-time structural repair hours had some year to year variation in the late 1990s and then gradually decreased after 2001. Therefore, depot hours related to structure appear to be well managed. However, because the KC-135s are true first generation turbojet aircraft designed only 50 years from the time man first began to fly, concerns regarding the ability to continue operating these aircraft indefinitely are intuitively well founded. The task force suggests that there may be other modifications to maintenance and deployment practices that could have a significant effect on further controlling corrosion. One example is to change the aircraft deployment rotation practice so that an aircraft is exposed to the most corrosive deployment environment right after it has undergone depot maintenance and is least susceptible to corrosion. A second option is to shelter aircraft assigned to severe corrosion environments. There also appears to be a disparity between Navy and Air Force field corrosion control practices for land-based aircraft, which should be examined.

Although corrosion is currently manageable, the sheer number of aged aircraft dictates a need to take action in the near term. The task force believes that a near term decision to commence tanker recapitalization must be made by FY07 to ensure replacement aircraft can start entering the inventory in sufficient numbers.

KC-135 FLEET GROUNDING FINDINGS

The Air Force did not present any analysis to support the assertion, found in USAF reports and briefing materials that the KC-135s are subject to a surprise fleet grounding. Given that this aircraft has been flown for an extended time and experienced intensive maintenance, it is just as likely the fleet will not experience grounding than it will (the task force could find no data to support either assertion). New aircraft have often provided the surprise that leads to grounding or to an early retirement of a block of aircraft. There are supporting examples in all the Services. Air Force examples include precautionary stand-downs for the B-2 in 1996 and 1998 and groundings of the F-117 in 1997 and the T-3 in 1998. The partial grounding of the KC-135 in late 1999/early 2000 resulted not from a surprise finding related to aging, but rather followed the discovery of a problem with stabilizer trim brakes/actuators installed after September 1999. A similar problem could occur to any aircraft at any time. So, although grounding is possible, the task force assesses the probability as no more likely than that of any other aircraft in the inventory of the Services. As with other maintenance programs, when an area of concern arises, concerted efforts have provided effective remediation. Such has been the case with the KC-135E engine strut (pylon) problem. The Air Force identified an interim repair and an ultimate solution, which is representative of their professional approach to the entire corrosion and aging aircraft challenge. Within the Services, fleet-wide maintenance issues traditionally receive careful management to avoid grounding. The maintenance problem is aggressively remediated. Quick, temporary repairs often address the grounding issue, while a permanent fix awaits a depot period. Commanders sometimes employ short-term operational restrictions, while still accomplishing the mission. And, in time of conflict, some additional risk may be accepted. None of these actions are unique or limited to the KC-135.

MODIFICATION PROGRAM FINDINGS

Nonetheless, aging remains a concern, primarily due to the sheer number of aircraft that will eventually be replaced. The Air Force has already spent a considerable amount of the money for improvement of the tanker force the GAO identified in their 1996 study on refueling aircraft. The report discussed reengining KC-135Es; replacing structural components; and adding multi-point refueling; the Pacer Compass, Radar, and Global positioning system (CRAG) modification; and ground collision avoidance systems. Although further reengining of KC-135E aircraft is still possible, the Pacer CRAG mod and considerable structural work have been completed since the report. Also, the Air Force has undertaken a significant rewiring program. As such, much of this cost avoidance opportunity has been foregone. Furthermore, in another area of cost avoidance, the task force was not presented with any evidence that the Air Force has actively examined the modification of used aircraft for the tanker mission as a cost avoidance strategy.

The driving issue here is the extremely low utilization rates of tanker aircraft. Given the nature of operations (i.e., the low utilization rates), any modern aircraft, new or used, will be able to remain in inventory for a very long time. Of course, newly manufactured airframes have the potential to last the longest; however, task force discussions with aerospace structures experts pointed out that early widebody aircraft (early 747s, DC-10s, A300s, etc.) benefit from far superior construction and maintenance practices related to corrosion than those associated with first generation transports.[5] Furthermore, these airframes can be operated for an indefinite period of time given the typically low operational tempo of tanker forces.

As these airframes can be purchased and modified to tanker configuration at significant savings over new procurement, the task force believes this option needs a thorough vetting by the Air Force, particularly in light of the fact that the aircraft fulfills an essential, though not advanced technology dependent, support mission and that there are several examples of successful aircraft conversions using early widebody aircraft. Notable among these is the Federal Express Corp. conversion of DC-10 aircraft to MD-10 aircraft. This

[5] Evidenced by the Air Force's KC-10 briefing, which noted "the KC-10 does not have corrosion issues beyond normal wear and tear at this time."

conversion, performed by The Boeing Company, fully modified an early widebody aircraft with an entirely new cockpit (digital electronic equipment; modern communications, navigation, and surveillance equipment; fully integrated flight management system; improved pneumatic and fuel management system; new wiring; etc.); refurbished engines; reliability improvements (systems refurbishments or replacements and new design equipment for certain high failure rate items); and structural improvements. FedEx expects a long service life from the aircraft and operates the aircraft on a common type rating with the MD-11, a current generation aircraft. Both aircraft are fully capable of operating in any foreseeable air traffic system. Although the exact number is proprietary, FedEx noted the program costs were easily half that of new procurement and that they undertook the program because of the savings involved over new procurement, given their low utilization rates driven by their system form (these utilization rates are significantly lower than that of commercial passenger operators, but at least three times greater than that of the tanker fleet). Another successful conversion involved two DC-10s to KDC-10 tanker configuration for the Royal Netherlands Air Force (at a unit cost of $45M each). These are boom-equipped aircraft without hose and drogue capability. They also incorporate the video Remote Aerial Refueling Operation system, which is planned for use on the Boeing KC-767.

As early widebody and current generation aircraft can be modified and modernized and then flown over long years of service, the task force believes this option must be seriously considered. This option can meet the mission need at considerably lower cost, thereby freeing up dollars for procurement in other areas that have a pressing requirement for more expensive advanced technology.

The Air Force has expressed an additional concern in reports and briefing material over continuing to have such a large percentage of the tanker fleet vested in the KC-135. A modification program would have an additional benefit of reducing the large dependence on a single type aircraft. Should a DC-10 to KC-10 modification program be undertaken, the benefits would be similar to that of adding a new type of aircraft, simply because the KC-135 portion of the force is so very large and adding any different type reduces the dependency.

The option to modify DC-10 aircraft also has the advantage of modifying to a known configuration currently in use in the Air Force. This will reduce non-recurring engineering expense and deliver a familiar platform with proven capability. It can also serve as a pilot program for subsequent programs that may convert other aircraft to medium tanker configurations at a time when the availability of those platforms makes the purchase price attractive.

Finally, a modification program can be structured to economically address both reliability issues and new capability requirements. Modified aircraft benefit from improvements in reliability engendered by new equipment. The airframe structure can be strengthened or refurbished as necessary. Digital communications and additional military features can be incorporated. The task force believes that for aircraft that have a basic support mission such as tanking, the alternative of modifying existing aircraft to achieve economic efficiencies must be thoroughly examined.

There are alternatives at the other end of the spectrum. While older aircraft may well serve as tankers in a traditional role in uncontested airspace, new strategic concepts may encompass a need to operate tankers in a more threatening environment. New operating concepts may require a more agile tanker with advanced protective features. Another alternative could incorporate a tanker within a fleet of aircraft with a common airframe performing several essential missions. In this case, working with manufacturers to develop options incorporating advanced technologies, for example, blended wing body aircraft with the ability to perform surveillance, reconnaissance, and intelligence gathering missions, as well as tanking, may be productive. However, the recapitalization issue cannot wait for the typical development cycle to provide a solution. An interim solution involving either the conversion of used aircraft or acquisition of new aircraft based on an existing airframe, among other options, will be required.

OPERATING AND SUPPORT COSTS

One of the Air Force's major arguments for beginning replacement of the KC-135 in the near term is that the "cost" of depot maintenance grew dramatically from FY1991 through FY2003 and can be expected to continue to grow at the same rate. The argument contains an implicit assertion that uncontrolled corrosion is the major factor in the cost growth. The task force investigated the major causes of cost and price growth in order to determine the best available basis for making projections.

Basis for the Air Force's Concern

The Air Force's argument is based on growth in the weighted average unit sales price for KC-135 airframe depot maintenance. That price rose from about $0.8 million in FY91 to about $7.3 million in FY04 (in then-year dollars) or about 18.5 percent compounded annually. The unit sales price (USP) for any given year is the price charged to the customer for an aircraft inducted into the depot in that year, although the customer is billed in the year the work is finished. USP is the product of a budgeted number of labor hours per aircraft and a budgeted price per hour. The latter is sometimes called the labor rate, but it is more properly called the sales rate since it includes labor, materials, and various overhead charges.

Prices versus Costs in a Working Capital Fund

The USP for any given year and the sales rate that goes into it are established during development of the budget and are fixed nine to twelve months before the budget year begins. At the time they are developed, prices have to be based on the results of operations in the year just completed and the budget estimate for the budget before Congress at the time. In a working capital fund, rates/prices are set so that projected revenue equals projected expenses (costs). Prices are adjusted, however, to recover unplanned prior year losses or return unplanned prior year gains. For gains or losses in year N, these adjustments usually occur in year N+2. Rates also are adjusted to maintain adequate cash reserves.

Why Costs and Prices Grew

During FY98 through FY00, the number of days an aircraft is in the depot (flow days) and backlog of aircraft in depot increased significantly. The Air Force attributes this to the unpredictability of major structural repairs and the depot's inability to identify them early in the process, increases in corrosion work, and the addition of two major modifications to the PDM process. In FY00 and FY01, the number of aircraft inducted was reduced from planned levels, the work flow was reengineered and improvements made on the shop floor, direct and engineering manpower was added, material support was enhanced, and the Pacer CRAG modification was eliminated from PDM work. These actions successfully eliminated the backlog and cut flow days almost in half.

Costs increased with the addition of labor and investments made. Paying for these increases while billing for fewer aircraft at previously established rates also caused large losses in FY00 through FY02. Table 1 shows unit sales prices, sales rates, cost rates, and profits or losses. (The cost rate for a year is the total costs for labor, materials, and overhead divided by total direct labor hours.) Data for FY04 and FY05 are budget numbers.

Table 1.

	Unit Sales Price ($M)	Sales Rate ($)	Cost Rate ($)	Profit or Loss ($M)
FY91	0.8			
FY92	1.5			
FY93	1.8			
FY94	1.7			
FY95	2.0	86.44		
FY96	2.2	96.74	88.56	-6.3
FY97	3.0	105.91	92.86	2.6
FY98	3.5	94.59	95.10	0.8
FY99	3.7	106.20	99.90	-2.5
FY00	3.5	94.34	127.13	-29.4
FY01	3.8	111.20	140.02	-62.1

FY02	6.0	162.91	131.41	-14.5
FY03	6.1	199.81	148.56	33.2
FY04	7.4	210.87	187.58	
FY05		191.50	199.35	

As the data in the table show, the cost rate jumped 27 percent from FY99 to FY00 and increased another 10 percent to FY01. As would be expected given lead times for setting USP and sales rates, sales rates in FY02 and FY03 reflected the cost increases in FY00 and FY01. Sales rates jumped even more sharply than cost rates, however, increasing 47 percent and 23 percent in FY02 and FY03, respectively. Some of this additional increase can be attributed to adjustments for prior year losses and the need to maintain adequate cash in the Air Force Working Capital Fund. If the entire $29 million lost in FY00 were included in the sales rate for FY02, the sales rate for those aircraft would have included about $25 per hour for loss recovery.

Costs Are a Better Basis than Prices for Projections

Because changes in prices lag changes in costs and because prices include adjustments for prior year losses and gains and to ensure adequate cash, these prices were artificially low before FY02 and artificially high thereafter. Therefore, the task force believes some measure of costs would provide a better basis for projections. Ideally, the task force would like to see the actual cost per aircraft over time. Computing that would require data that are not available in any automated system, however; so the task force inquiry focused on cost rates.

What Was Learned About Cost Rates

Table 2 shows the components of the cost rate (excluding a category called "other direct," which makes a trivial contribution to the total). Cost rates increased sharply in every category from FY99 to FY00. Production overhead shows the largest absolute and percentage increase thereafter.

Table 2.

Cost Rates (dollars per hour)				
	Direct Labor	Direct Material	Production Overhead	General & Administrative
FY96	27.59	17.30	32.11	11.56
FY97	27.52	17.38	34.31	13.64
FY98	29.54	19.65	33.50	10.83
FY99	31.00	20.77	36.78	11.36
FY00	38.19	29.05	44.25	15.63
FY01	37.78	29.75	53.91	14.58
FY02	34.84	31.25	50.32	14.99
FY03	35.50	34.37	59.53	19.06

As the name suggests, direct labor[6] and direct material are directly related to the amount and difficulty of work on the airframe. The changes in the manpower component of cost rates are consistent with the permanent addition of manpower to reduce flow days and a temporary addition to eliminate the backlog. Enhanced material support for the shop floor likely contributed to the initial increase in the direct material component of the cost rate. The Air Force also attributes increases to major structural repairs, replacement of stabilizer trim actuators and stress panels in vertical and horizontal stabilizers, and major modifications.

Both production overhead and general and administrative (G&A) include costs that are not directly related to aging aircraft such as charges for services provided by Defense Finance and Accounting Service (DFAS) and Defense Information Systems Agency (DISA), information technology costs, and a share of various overhead costs not related to a specific depot product. These costs grew from $20 million in FY00 to a projected $67 million in FY05. G&A costs are entirely in this category, while production overhead includes costs of both types. For example, it includes the engineering manpower that was added and the investments that were made to reduce flow days as well as some overtime costs. The Air Force answered three sets of questions regarding airframe depot maintenance costs.

6 For a fixed number of flow days

Unfortunately, the task force has not been able to divide the production overhead component of cost rates between costs related and unrelated to aging aircraft when the inquiry was terminated.

A Projection of Cost Rate Increases

The Air Force determined that USP data from FY91 through FY03 fit a compound growth curve better than it fit a linear growth curve. Nothing that the task force learned about the reasons for cost growth suggests that growth is non-linear. Additionally, the change in depot maintenance process in FY00 argues for using only data from FY00 onward. Therefore, the task force believes a linear projection using cost data (not price data) from FY00 through FY05 provides the best estimate of future cost rates. Such a projection shows growth of $14.88 per hour per year (with an R^2 value of 0.838).

CHAPTER 3. FUTURE NEEDS FOR AERIAL REFUELING TANKERS

The major driver for future aerial refueling needs is the number and type of nearly simultaneous "major" operations. Demands on aerial refueling are particularly stressed when time is of the essence for the mission (to respond and stop the dying, stop the killing, stop the aggression, stop the use of WMD, etc.) and when local infrastructure is immature. There are a myriad of other factors that have second order effects on fleet characteristics. These include capabilities to operate on short runways, to refuel multiple aircraft simultaneously, to receive as well as offload fuel, and to refuel unmanned platforms.

The scenario-based Tanker Requirements Study 2005 found that a fleet of 500–600 aircraft (KC-135R equivalents) and an increased crew to aircraft ratio would be needed to support the SIOP mission and one major theater war (MTW). The study examined the sensitivity of fleet size to number and type of nearly simultaneous missions —it did not, however, explore how these missions might change in the future. It has not been updated to reflect the transition from a two MTW sizing strategy to a 1-4-2-1 strategy. Current plans are to update the requirements in the Mobility Capabilities Study, which is to be initiated in May 2004.

The 500 - 600 fleet size finding, also the current fleet size, is not inconsistent with OIF experience. The number of tanker aircraft supporting OIF directly and indirectly peaked at 319 out of the available 389 fully mission capable aircraft, with 182 of these tankers forward deployed to CENTAF. While there were other fully mission capable aircraft not in depot maintenance that could have been made available, one can envision major theater campaigns of greater scale and intensity than OIF. The tanker force employed in OIF could have been capable of a greater intensity fight (i.e., more sorties, more offloads, more receivers) but it is difficult to gauge OIF intensity from available data. Further, the task force did not examine whether OIF could have been executed with fewer tanker aircraft.

Table 3. Tanker Tasking during OIF (Snapshot on 27 March '03)

	Total Active Inventory	Possessed	FMC	Tasked
Total KC-10s	59	50	45	48
Total KC-135s	480*	400	344	271**
Totals	539	450	389	319

** This data was obtained from the Air Force and it is uncertain why the Total Active Inventory of KC-135s is listed as 480 versus the base inventory level of 541.*

*** 14 of these missions were in support of homeland defense Noble Eagle requirements.*

There are new missions, new modes of operations, and changing operational situations that could increase the demand for and nature of aerial refueling. One is homeland defense in which sizeable number of interceptor aircraft may need to be airborne over major cities for extended periods. Up to 122 KC-135 equivalent tankers could be needed for this mission depending on the number of patrol aircraft aloft. The shedding of organic firepower by U.S. ground forces and concomitant increased dependence on responsive firepower delivered from loitering attack aircraft is another source of increased demand for aerial refueling. Other possibilities that could influence the size of the tanker fleet are more U.S. reliance on sea-based operations over long distances, reduced overseas basing infrastructure, and a transition to smaller but more flexible tactical tankers in-theater in order to avoid large concentrations of KC-135 and KC-10 tankers at the few airbases that have sufficient runway lengths for large tankers. The ability to leverage the design of the F/A-22 and F-35 to require only one tanking on either mission ingress or egress could also be significant. Finally, if the remaining B-52s are reengined with more modern, fuel efficient engines, the fuel savings could substantially reduce strategic and tactical force demands on tanker assets. As an example, a reengined B-52 on a 10,000 mile mission from CONUS to Afghanistan and back would require only one tanker on the return leg versus current requirements for a tanker on both legs. The fuel offload demand would be reduced from 276,000 pounds to 118,000 pounds.

REVIEW OF DOCUMENTS AND FUTURE STUDY GUIDANCE

Tanker Requirement Study 05

The last major study on aerial refueling tankers was the Tanker Requirements Study 2005 (TRS-05) that was completed in March 2001 but was never officially promulgated due to questions about the methodology used to aggregate the numbers of tanker needed for each of the missions. It was conducted by the Air Mobility Command (AMC). The TRS-05 had the participation of the major Combatant Commanders and Joint staff but neither the Navy and Marine Corps nor the Army. It considered major theater wars in southwest Asia and northeast Asia as well as needs during strategic nuclear alerts and employment. Small-scale contingencies and Special Operations Forces were also considered. The tanker requirement for each phase was calculated to meet both receiver fuel offload and aircraft/boom availability demands. The tanker requirement for a given scenario was phased upon the peak day plus operations withholds. It was modeled in accordance with the Mobility Requirements Study warfight solution, which is no longer extant.

Deployment requirements were determined in accordance with Mobility Requirements Study (MRS)-05 Time Phased Deployment Data.

According to an unclassified briefing provided by OSD (PA&E) for the DSB Task Force on Aerial Refueling Requirements, TRS-05 identified the need for approximately 500 –600 KC-135R equivalents and approximately 900–1000 aircrews. None of the scenarios examined identified excess tanker capability. There were identified shortfalls for both aircraft and crews, with work-arounds available to mitigate some of the shortfalls.

The study also identified other tanker shortfalls, driven in large part by the high number of KC-135s in the depot, a situation that has been rectified by good management of the depot workloads at the Oklahoma City Air Logistics Center and the two commercial depots.

In May 2004, a Mobility Capabilities Study will be initiated by the Joint Staff and OSD (PA&E); the study is scheduled for completion in March 2005. It will use as a baseline the 1-4-2-1 sizing strategy vice the 2 MTW scenario of TRS-05.

Tanker Recapitalization: Aging Aircraft Challenges paper from the Air Mobility Command (AMC), 2003

This paper asserts that "AMC must begin recapitalization of its aging tanker fleet now … that the average age of the KC-135s are 42+ years." The paper expresses concern over the "unknown unknowns," which might occur with a fleet of aircraft of this age. The paper also expresses concern over increased depot costs (+59 percent) and increased contractor costs (+113 percent). Replacing a 541-aircraft tanker fleet will take decades, according to the paper. "Operating 70+ year old fleet is unprecedented."

The paper further highlights KC-767 improvements in comparison to the KC-135 in the following metrics:

1. Cargo/Pax benefit
2. Aero Medical Evacuation capable
3. ISR capability
4. Boom and drogue capable

Mission Need Statement (MNS) AMC 004-01 Future Air Refueling Aircraft, 1 November 2001

This MNS uses as its basis the TRS-05 referenced above. It is designed to support the FY 2002-2007 Defense Planning Guidance, the National Security Strategy, and the National Military Strategy across the entire spectrum of conflict to a MTW. It states that "air refueling allows airpower forces to increase levels of mass, surprise, economy of force, flexibility versatility, and maneuverability and can concentrate more assets for offensive operations." It further states that "the air refueling aircraft should have sufficient range and offload capability to support both inter- and intra-theater missions, be able to refuel the full range of receiver aircraft within a safe operation envelope, and be capable of carrying and offloading a fuel type other than the primary fuel used by the new aircraft. The aircraft should be capable of refueling receptacle and probe-equipped receiver aircraft on the same mission, as well as refueling multiple aircraft simultaneously."

Operational Requirements Document (ORD), AMC 004-01-B, Air Refueling Aircraft Program, 22 October 2002

The ORD states that the system will support the Defense Planning Guidance FY 2003-2007. "The proposed replacement system is a specially modified, commercially available aircraft able to offload fuel via boom and drogue as well as on-load fuel from a boom-equipped tanker**."** The ORD goes on to state that the TRS-05 determined the number of tanker and aircrews needed for a variety of war planning scenarios."

Analysis of Alternatives (AoA) Guidance for KC-135 recapitalization tasking dated 24 February 2004

The acting Undersecretary of Defense for Acquisition, Technology and Logistics tasked the Secretary of the Air Force to conduct an AoA to analyze potential courses of action for recapitalizing the tanker fleet. The AoA is due to complete August 2005. The MNS for Future Air Refueling aircraft, AMC-004-01, described above, will be used as the beginning point for evaluating alternatives as well as the Defense Planning Scenarios, and the FY 2006-2011 Strategic Planning Guidance (SPG). The tasking states, "the AoA will define alternative tanker capabilities and critical parameters such as speed, range, ground footprint, fuel offload capabilities, maximum landing weight, cargo payload, passenger payload, fuel burn rate, multipoint capability, multi-fuel capability, tanker-receiver capability (including the capability to refuel UAVs), receiver envelope, special mission requirements, ground turn times, mission capable rates, depot (or inversely, availability) rates, sortie rates, etc."

The AoA further tasks the U.S. Air Force to consider a broad range of platform alternatives. As its baseline, the AoA states that it "defers any action on recapitalizing the tanker fleet. Operates the FY05 programmed fleet as is (59 KC-10, 417 KC-135R and 73 (sic) KC-135E) until 2045. An alternate baseline includes initial KC-767A profile and associated KC-135E retirement schedule. Defers any additional recapitalization action. Operates the fleet until 2045."

The AoA then suggests a series of options:

1. Retaining and reengining the KC-135Es to KC-135Rs
2. Retire the remaining KC-135Es
3. Purchase a commercial Derivative Aircraft. Consider B-767, B-7E7, B-737, Airbus 310 and 330, and legacy tanker aircraft lines
4. Purchase a military derivative aircraft, considering C-130J and C-17
5. Acquire and modify used aircraft, for example, modify used B-767, B-747, DC 10, MD11, A310, or A330 aircraft
6. Develop and procure a new military tanker
7. Develop and procure an unmanned aerial tanker

The Boeing 767 production line is nearing the end of its run. Unless new sales of the 767 emerge soon, it may be necessary to shut down the line in the summer of 2005. In order to keep the Boeing 767 as a viable alternative, the completion of the tanker AoA and the MCS must be accelerated to the fall of 2004.

In addition, if DoD believes the 767 is a viable candidate as a replacement tanker, then DoD should commence negotiating a smart shutdown of the Boeing 767 production line to minimize restart costs. The 1993 RAND Corporation Report *Reconstituting a Production Capability: Past Experience, Restart Criteria, and Suggested Policies*[7] provides significant detail on all aspects of a smart shutdown including economic and time response advantages. A shutdown as short as one year can be economically advantageous; other options such as maintaining the production line in a warm status should also be explored.

[7] The report can be ordered from the RAND Corporation (MR-273-ACQ) or viewed at http://stinet.dtic.mil/cgi-bin/fulcrum_main.pl?database=ft_u2&searchid=108370311628823&keyfieldvalue=ADA288463&filename=%2Ffulcrum%2FTR_fulltext%2Fdoc%2FADA288463.pdf

The smart shutdown needs to be commenced soon enough, approximately eighteen months before line termination, to capture the production tools and processes of subcontractors. Photos and videotapes of the manufacturing process and detailed interviews of the manufacturing team greatly assist in the rapid and economic restart of a production line. DoD should view investment in the smart shutdown as an insurance policy in case the tanker AoA and MCS validate the Boeing 767 as the replacement tanker aircraft. Without a small, upfront investment in a smart shutdown the restart cost could be high enough to prevent the 767 from being a viable candidate or significantly raise the overall cost of the tanker recapitalization program.

CHAPTER 4. CONCLUSIONS

As a result of its findings and deliberations, the task force believes that prior to embarking on a major tanker recapitalization effort, the tanker AoA and the MCS should be completed to allow informed decision making. The task force saw convincing evidence that the KC-135 Operating and Support (O&S) costs are not growing at the rate observed in the 2001–2003 timeframe which may have contributed to the decision to accelerate the tanker recapitalization.

The task force observed an excellent USAF corrosion control program for the KC-135s in both the depot and in the field. There may be additional improvements that could increase the effectiveness of the field corrosion control efforts. The government aeronautical structural experts, academic researchers, and commercial entities with whom the task force consulted all concluded that KC-135 corrosion is manageable. Additionally, the task force found no evidence that there is a real, near-term danger of fleet-wide grounding due to corrosion problems.

The tanker requirement documents need to be updated to reflect changing concepts of operations and the current 1-4-2-1 force sizing strategy. Such an update is planned to begin in May 2004 (the MCS), with a completion date of March 2005. The task force recommends the completion date of both the tanker AoA and the MCS be accelerated to the fall of 2004. The MCS should recognize the impact of other potential program changes such as reengining the B-52. The use of commercial tanking is another possibility to relieve pressure on the organic tanker force for CONUS training and homeland defense missions.

The size of the KC-135 fleet demands that recapitalization start in a reasonable timeframe, but not necessarily before the completion of the AoA and the MCS. Replacing a fleet that was procured at rates from 75 to 100 aircraft per year with the current forecast of future defense funding levels will require a sustained and long-term procurement. However, such a recapitalization effort doesn't necessarily mean new aircraft for this support mission. **The task force suggests serious consideration be given to:**

- **Purchasing and converting used aircraft for aerial refueling**. The task force focused on one option, converting some number of available DC-10-30s to KC-10s. Future recapitalization could also involve the conversion of used Boeing 767 or 737 aircraft as they become available. The results of the tanker AoA and MCS should guide DoD as to the proper mix and number of tanker aircraft.
- **Arranging for contractors to provide some of the aerial refueling needs** —especially applicable, but not limited to the homeland defense mission. The Navy currently uses a commercial 707 rigged for drogue refueling. This aircraft is operated by the Omega Aerial Refueling Service, Inc., which has expressed interest in purchasing retired KC-135Es so it could offer this service for Air Force aircraft as well.
- **Working with manufacturers of large airframes to determine the potential to configure new commercial aircraft for the aerial refueling role. It is important not to preclude future opportunities from new generation aircraft that might be lost through a commitment to major recapitalization within the next two years.**

APPENDIX I. TERMS OF REFERENCE

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DEPUTY SECRETARY OF DEFENSE
1010 DEFENSE PENTAGON
WASHINGTON, DC 20301-1010

FEB 1 2004

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Terms of Reference - Defense Science Board Task Force on Aerial Refueling Requirements

I am requesting you form a Defense Science Board (DSB) Task Force to evaluate current aerial refueling capability and future Department of Defense (DoD) aerial refueling requirements. The Task Force's evaluation should include recommendations for meeting future aerial refueling requirements.

Most legacy and projected DoD aircraft require aerial refueling to conduct operations across the entire spectrum of DoD missions. As the Department transforms itself to meet the challenges of the 21st century, existing aerial refueling capabilities may or may not meet future needs. New systems and capabilities are being developed (e.g. F/A-22, the Joint Strike Fighter, Small Diameter Bomb, unmanned aerial vehicles, proposed strategic strike capabilities, etc.) which may drastically alter future requirements for aerial refueling. Current long range air mobility and strike aircraft represent a significant and pervasive demand on aerial refueling assets. In addition, it is quite possible that opponents have identified refueling assets as a necessary component of U.S. success and will target these assets in future conflicts, representing an attrition of aerial refueling capability that we have not experienced in the past.

The Task Force should assess current and future requirements with respect to both legacy systems and missions, and take into account proposed future systems and capabilities. The Task Force shall have access to the historic reviews of the Air Force, General Accounting Office, and other DoD departments, and request any data collection, or data development required to fill in analytical gaps. Using best estimates of requirements for 2010, 2020, and 2030, the Task Force should assess the following options with respect to DoD aerial refueling capability:

a. Retain the requisite number of assets to maintain current capability. The Task Force should identify any issues which may affect the ability of the current aerial refueling fleet to continue to operate, to include potential affects of corrosion, the estimated length of service existing for current assets, means to mitigate these issues, and estimated costs of maintaining these assets as the fleet ages.

b. Perform a service life extension on the requisite number of existing aircraft. The Task Force should identify the expected lifetime of refurbished aircraft to

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bound the potential cost of this option.

c. Acquire new refueling capabilities. As a minimum, the Task Force should assess the acquisition of new aircraft, modification of used aircraft to perform the aerial refueling mission, and development of unmanned aerial vehicles as an aerial refueling tanker. The Task Force should include an estimate of costs and quantify an acquisition rate for any new capabilities.

d. Evaluate other methods to address refueling needs. For example, there may be sufficient financial incentive to re-engine existing fleets of aircraft with more fuel efficient engines which would lower overall demand. Development of suitable doctrine to employ Small Diameter Bombs or other future precision weapons may reduce the number of required sorties and similarly lower future demand. The Task Force should attempt to quantify these trends and estimate costs of these capabilities for comparison to the costs of other refueling options.

In arriving at their conclusions, the Task Force should not be bound by any one option and may explore options not discussed above.

The Task Force should provide a final report by April 30, 2004. The Task Force should provide their report directly to the Secretary of Defense.

Administrative support and funding will be provided by Mr. Michael W. Wynne, Acting USD(AT&L)and Dr. Glenn Lamartin, Director, Defense Systems. Admiral Don Pilling, USN (Ret) and Dr. Ted Gold will serve as Co-Chairmen of the Task Force. Colonel Bill Story, Defense Systems (Air Warfare), will serve as Executive Secretary; and Lieutenant Colonel David Robertson, USAF, will serve as the DSB Secretariat Representative.

The Task Force shall have access to any classified information needed to develop its assessment and recommendations.

The Task Force will be operated in accordance with the provisions of P.L. 92-463, the "Federal Advisory Committee Act," and DoD Directive 5105.4, "The DoD Federal Advisory Committee Management Program." It is not anticipated that this Task Force will need to go into any "particular matters" within the meaning of Section 208 of Title 18, U.S. Code, nor will it cause any member to be placed in the position of acting as a procurement official.

Paul Wolfowitz

APPENDIX II. TASK FORCE MEMBERSHIP

CHAIRMAN

ADM Don Pilling, USN (Ret.)	Logistics Management Institute

TASK FORCE MEMBERS

Mr. Irv Blickstein	RAND
Ms. Deborah Christie	Institute for Defense Analyses
Dr. Robert Howard	Private Consultant
Mr. Robert Rachor	Federal Express Corp.

EXECUTIVE SECRETARY

Col William Story, USAF	OUSD(AT&L)/DS-AW

DSB REPRESENTATIVE

Lt Col David Robertson, USAF	DSB Secretariat

GOVERNMENT ADVISORS

Ms. Kathleen Conley	PA&E
Mr. Kal Leikach	NAVAIR
Mr. David Merrill	AMC
Dr. Alan Somoroff	NAVAIR

STAFF

Ms. Stacie Smith	Strategic Analysis, Inc.

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APPENDIX III. BRIEFINGS

February 3, 2004: Arlington, VA	
BRIEFER	***TOPIC***
Maj Bill Uptmor (AF/XOR) Maj Bob Keirstead (AF/XPP)	Tanker Force Overview: Operational Capabilities/ Force Structure and Recapitalization
LtCol Tom Jackson (AF/ILM)	Tanker Corrosion Issues
Dr. Laura Williams, PA&E Ms. Kathleen Conley, PA&E	Tanker Requirements Briefing
February 17-18, 2004: Arlington, VA	
Mr. Mike Kennedy Mr. Dave Orletsky Dr. John Stillion	RAND Tanker Recapitalization Alternatives Study
Mr. Dyke Weatherington	UAV Capabilities and Requirements
Mr. Daniel Thompson, AFRL	Joint Automatic Aerial Refueling Program
Mr. Chris Bolkcom Mr. Ron O'Rourke	Congressional Research Service Tanker Perspectives
Mr. Dale Moore	NAVAIR Aircraft Corrosion Control and Prevention Program
Mr. Chris Holder, NAVAIR	KC-130 Corrosion Management
CAPT Michael Fralen, USN Maj Steve Primm, USMC	USMC KC-130 Requirements
Mr. Robert Rachor, Federal Express	FedEx Aging Airplane Safety Purchase and refurbishment of used MD-10s
Mr. Gale Matthews, Omega Aerial Refueling Services, Inc	Omega's Tanker Modification Program
March 9-10, 2004: Tinker Air Force Base, Oklahoma City, OK	
Mr. Jack Srnec	KC-135 Aging Aircraft

Mr. Tom Ramsey	Maintenance Program Review C/KC-135 ASIP & FSIP Briefing
Col Ron Blickley, USAF	KC-135 Depot Maintenance Tour
Mr. Sam Champlin	KC-10 Program Update DC-10 Conversion
Lt Col John Graham, USAF AMC	Tanker Allocation and Scheduling
Lt Col Gerardo Inumerable, Jr., USAF AMC	AMC KC-135 Maintenance Program
Lt Col Spike Halton, USAF AMC	AMC Tanker Recapitalization
March 24, 2004: Arlington, VA	
LtGen James Cartwright, USMC	J-8 Perspective
Col (sel) Michael Cassidy, USAF	Tanker Programming and Budgeting
Mr. Sam Kleinman Mr. Brent Boning Mr. Peter Francis	CNA KC-135 Study
Mr. Charles Nemfakos	National Defense Sealift Fund
Dr. James Woolsey Dr. Steve Balut	IDA KC-767 Pricing Study
April 6, 2004: Arlington, VA	
Mr. William Abbott	Battelle Study on Corrosion Monitoring at USAF Sites

APPENDIX IV. COST GROWTH

One of the Air Force's major arguments for beginning replacement of the KC-135 in the near term is that the "cost" of depot maintenance grew dramatically from FY1991 through FY2004 and can be expected to continue to grow at the same rate. The first part of that statement is true, although for reasons described below, it is somewhat misleading. The DSB task force investigated the major causes of cost and price growth to determine the best available basis for making projections.

RELEVANT AIR FORCE STUDIES

The Air Force's *KC-135 Economic Service Life Study* (ESLS) released in February 2001 projected airframe depot maintenance and total operating and support (O&S) costs for retaining as much as possible of the KC-135 fleet from FY01 through FY40. Costs are shown in FY00 dollars. The study observed that the depot hourly labor rate was anticipated to grow from $111.20 in FY01 to $160.00 in FY02 due to a narrowing of the depot's overhead base. It assumed that this rate would grow at 1 percent annually (simple escalation) thereafter. This assumption along with assumptions about growth in hours per aircraft led to a projection of airframe depot maintenance costs that shows a growth rate of 3.2 percent compounded annually. Total O&S costs, which include engine depot maintenance, unit manpower, and other unit costs, show growth of only 0.9 percent compounded annually. (The study's number of 6 percent for growth in depot costs appears to use a different definition of growth rate.)

The Air Force's *KC-135E Business Case Analysis* (BCA) released in May 2003 also projected airframe depot maintenance and total O&S costs. Unlike the ESLS, the BCA looked at the FY04 President's budget proposal to procure 100 KC-X and replace all KC-135Es. It shows costs from FY03 through FY17 in then-year and FY03 dollars. The BCA observed that the weighted average unit sales price (USP) for KC-135 airframe depot maintenance rose from about $0.8 million in FY91 to about $7.3 million in FY04 (in then-year dollars) or about 18.5 percent compounded annually. (In FY04 constant dollars, this growth rate is about 16.8 percent.) The BCA revised the ESLS' cost estimate for airframe depot maintenance on the assumption that costs would continue to grow at that rate, updated the ESLS estimate for personnel and modifications to reflect the FY04 budget, and added KC-X O&S costs. (The study does not discuss the basis for KC-X costs.) The result showed growth in total O&S of 6.5 percent compounded annually in constant dollars.

DATA PROVIDED TO THE DSB TASK FORCE

The table below shows data on the USP from the BCA. It also shows a variety of price and cost data related to KC-135 airframe depot maintenance that were provided by the Air Force to the DSB in April 2004. The FY05 data was not available when the BCA work was done in 2003

	Unit Sales Price ($M)	Sales Rate ($)	Sales Rate less G&A	Revenue Rate ($)	Cost Rate ($)	Profit or Loss ($M)
FY91	0.8					
FY92	1.5					
FY93	1.8					
FY94	1.7					
FY95	2.0	86.44	68.74			
FY96	2.2	96.74	77.41	83.32	88.56	-6.3
FY97	3.0	105.91	90.68	94.75	92.86	2.6
FY98	3.5	94.59	83.62	95.63	95.10	0.8
FY99	3.7	106.20	92.63	98.14	99.90	-2.5
FY00	3.5	94.34	84.11	101.75	127.13	-29.4
FY01	3.8	111.20	100.35	91.44	140.02	-62.1
FY02	6.0	162.91	142.42	121.96	131.41	-14.5
FY03	6.1	199.81	175.11	171.22	148.56	33.2
FY04	7.4	210.87	159.06	204.45	187.58	
FY05		191.50	169.91	190.32	199.35	

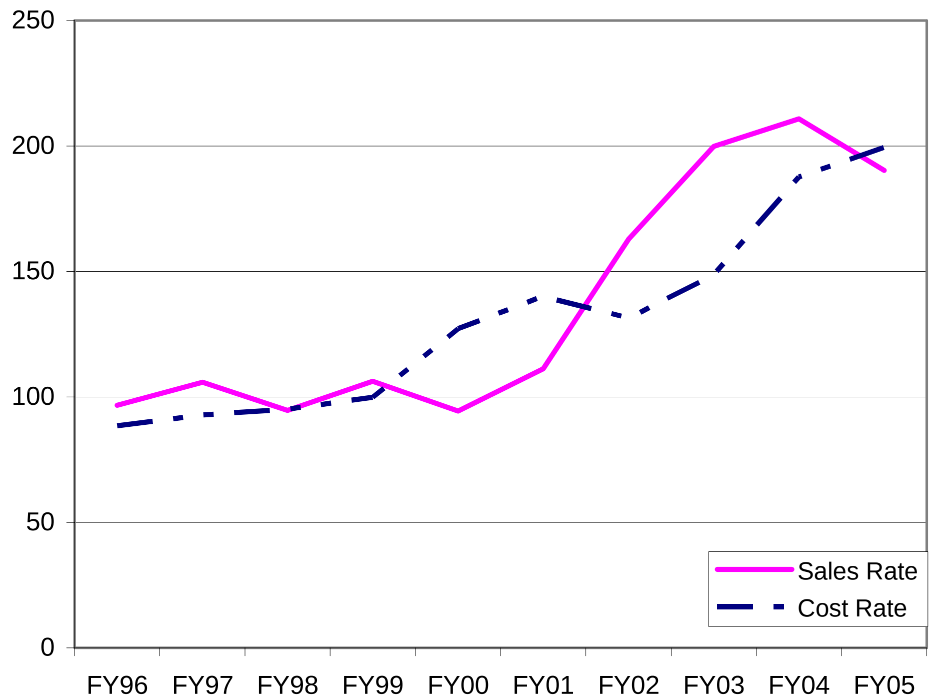
The USP for any given year is the price charged the customer for an aircraft inducted into the depot in that year; it is charged in the year the work is finished. USP is the product of a budgeted number of labor hours per aircraft and a budgeted price per hour. The latter is sometimes called the labor rate (as in the ESLS), but it is more properly called the hourly sales rate since it includes labor, materials, and various overhead charges.

The revenue rate for any given year is the weighted average sales rate for aircraft produced (i.e., completed) in that year. The cost rate for any given year is the total cost of airframe depot maintenance (including labor, materials, and overhead) divided by the total direct labor hours worked that year, whether these hours were worked on aircraft carried in from the previous year or on those inducted during that year. Both of these rates are after-the-fact reflections of the results of operations, except in FY04 and FY05 where they are budget numbers.

Data for FY04 are the basis for the budget now being executed. Data for FY05 are the most recent projections. Data on sales rates provided by the Air Force to the USD(C) and DPA&E in February 2004 showed a projection of $237.28 for FY05. The decision to slip the overhaul of the engine struts on the E model to FY06 resulted in the lower projection of $190.32 shown in the table.

The figure below plots sales rate and cost rate data.

Sales and Cost Rates



During FY98 through FY00, the number of days an aircraft is in the depot (flow days) and backlog of aircraft in depot increased significantly. The Air Force attributes this to the unpredictability of major structural repairs and the depot's inability to identify them early in the process, increases in corrosion work, and the addition of two major modifications to the PDM process. In FY00 and FY01, the number of aircraft inducted was reduced from planned levels, the work flow was reengineered and improvements made on the shop floor, direct and engineering manpower was added, material support was enhanced, and the Pacer CRAG modification was eliminated from PDM work. These actions have been successful in eliminating the backlog and cutting flow days almost in half.

The addition of labor and the investments increased costs. As the data in the table and figure show, the cost rate jumped 27 percent from FY99 to FY00 and increased another 10 percent to FY01. Paying for these increases while billing for fewer aircraft also caused large losses in FY00 through FY02.

The USP for any given year and the sales rate that goes into it are established during development of the budget and are fixed about 9-12 months before the budget year begins. At the point they are developed, they have to be based on the results of operations in the year just completed (probably preliminary results) and the budget estimate for the budget then before Congress. In working capital fund theory, rates/prices are set so that projected revenue equals projected expenses (costs). Also in theory, they are adjusted to recover unplanned prior year losses or return unplanned prior year gains. For gains or losses in year N, these adjustments usually occur in year N+2. For several years before FY02, however, sales rates did not include this adjustment. Rates also may be adjusted to maintain adequate cash reserves.

As would be expected given lead times for setting USP and sales rates, sales rates in FY02 and FY03 reflected the cost increases in FY00 and FY01. Sales rates jumped even more sharply than cost rates, however, increasing 47 percent and 23 percent in FY02 and FY03, respectively. Some of this additional increase can be attributed to adjustments for prior year losses or gains and the need to maintain adequate cash in the AF WCF.

As the table shows, losses in FY99 through FY02 totaled \$108.5M. The task force does not know how much loss was recovered in any single year, but an example will demonstrate the potential magnitude. In FY02, 38 aircraft were planned for induction at about 31,000 hours per aircraft. If the entire \$29 million lost in FY00 were included in the sales rate for FY02, the sales rate for those aircraft would have included about \$25 per hour for loss recovery. Whatever the amount, the return to normal WCF policy with regard to cost recovery undoubtedly makes comparisons of prices before and after FY02 misleading.

Other data provided by the Air Force show the magnitude of recent gain/loss and cash adjustments. The table below shows sales rates for FY04 and FY05 exclusive of any such adjustments and the magnitude of adjustments in those years.

Composition of Sales Rates		
	FY04	FY05
Direct and Production Overhead	159.06	169.91
G&A (excluding adjustments)	29.55	29.44
Sub-Total	188.61	199.35
Carry Over Adjustment*	15.72	-16.14
Other Adjustments	6.52	8.29
Total Sales Rate	210.87	191.50

** Carry over adjustments correct for anticipated losses or profits on aircraft that are carried over from the previous year.*

Because changes in USP and sales rates lag changes in costs and because they include adjustments for prior year losses and gains and to ensure adequate cash, these "prices" were artificially low before FY02 and artificially high thereafter. Therefore, the task force believes some measure of costs would provide a better basis for projections. Ideally, the task force would like to see the actual cost per aircraft over time. Computing that would require data on the number of hours worked on each aircraft in each year it was in depot. Unfortunately, it is understood that such data are not available in any automated system. Therefore, the following discussion focuses on cost rates.

WHAT WAS LEARNED ABOUT COST RATES

The table below shows the components of the cost rate (excluding a category called "other direct," which make a trivial contribution to the total). Every category grew significantly from FY99 to FY00, and production overhead had the largest percentage and absolute growth thereafter.

Cost Rates (dollars per hour)				
	Direct Labor	Direct Material	Production Overhead	General & Administrative
FY96	27.59	17.30	32.11	11.56
FY97	27.52	17.38	34.31	13.64
FY98	29.54	19.65	33.50	10.83
FY99	31.00	20.77	36.78	11.36
FY00	38.19	29.05	44.25	15.63
FY01	37.78	29.75	53.91	14.58
FY02	34.84	31.25	50.32	14.99
FY03	35.50	34.37	59.53	19.06

As the name suggests, direct labor[8] and direct material are directly related to the amount and difficulty of work on the airframe. The changes in the manpower component of cost rates are consistent with the permanent addition of manpower to reduce flow days and a temporary addition to eliminate the backlog. Enhanced material support for the shop floor likely contributed to the initial increase in the direct material component of the cost rate. The Air Force also attributes increases to major structural repairs, replacement of stabilizer trim actuators and stress panels in vertical and horizontal stabilizers, and major modifications.

Both production overhead and G&A include costs that are not directly related to aging aircraft such as charges for services provided by DFAS and DISA, information technology costs, and a share of various overhead costs not related to a specific depot product. These costs grew from $20M in FY00 to a projected $67M in FY05. In that year, they contributed $48.21 to the cost rate of $199.35. G&A costs are entirely in this category, while production overhead includes costs of both types. For example, it includes the engineering manpower that was added and the investments that were made to reduce flow days as well as some overtime costs. The Air Force answered three sets of questions regarding airframe depot maintenance costs. Unfortunately, the task force had not been able to divide the production overhead component of cost rates between

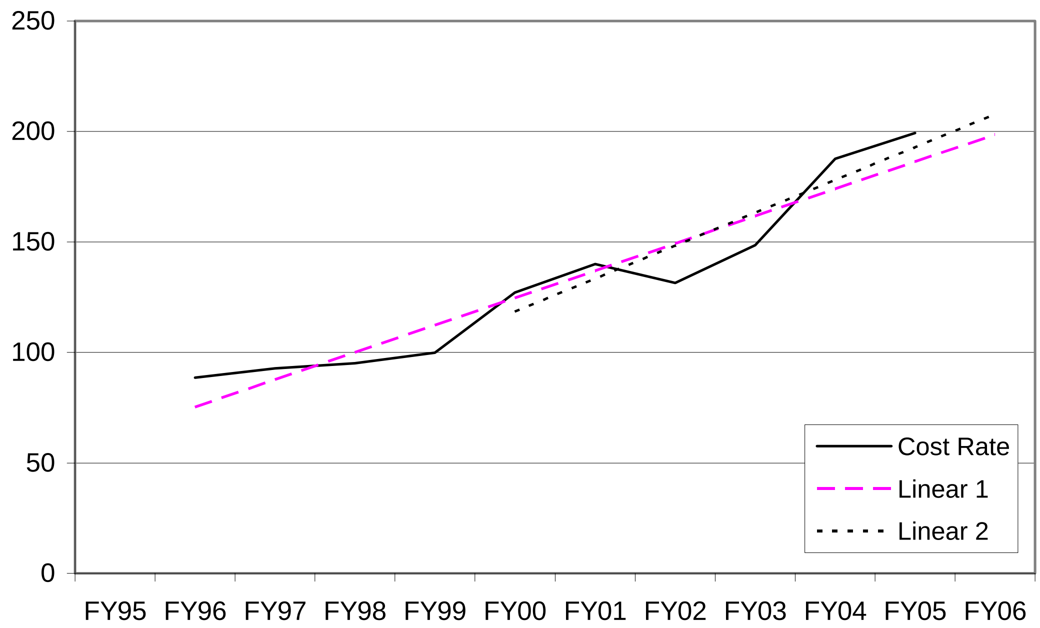
[8] For a fixed number of flow days

costs related and unrelated to aging aircraft when the inquiry was terminated.

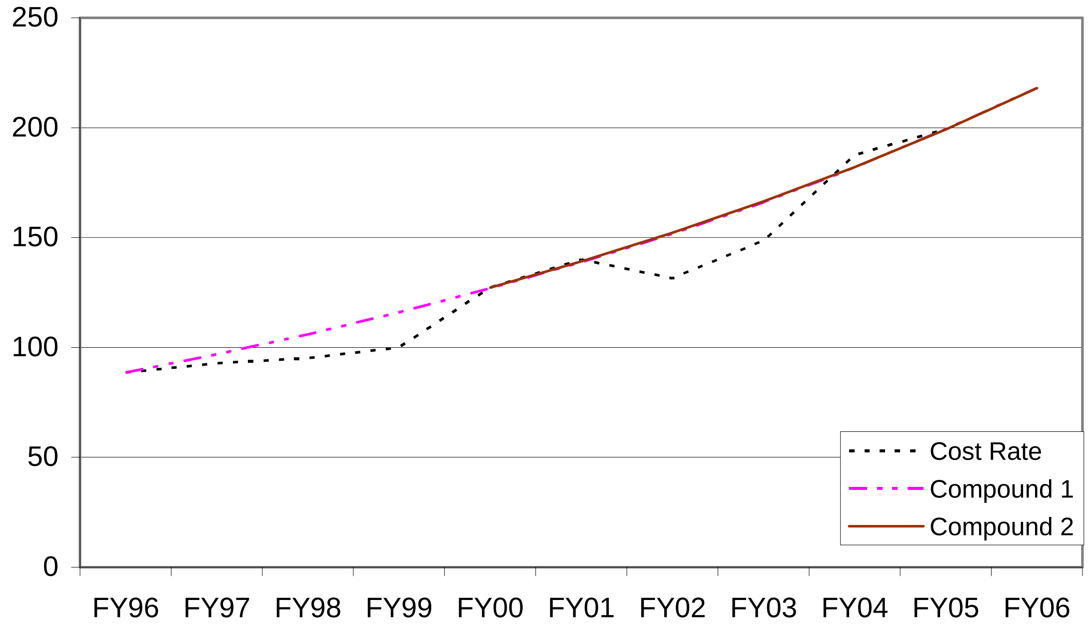
WHAT THIS SUGGESTS ABOUT FUTURE RATES

The Air Force determined that USP data from FY91 through FY03 fit a compound growth curve better than it fit a linear growth curve. The task force already has explained why it believes some measure of costs is a better basis for projections than these measures of "price." One must determine, however, which years to use in making a projection and what type of curve best fits the data.

The first figure shows two linear growth curves for cost rates, one using all the data and one using just data from FY00 through FY05. In the first case, costs grow by $12.33 per year; in the second case, they grow by $14.88 (with an R^2 value of 0.838).



The final figure shows the cost rate and two compound growth curves, one using all the data and one using just data from FY99 through FY05. The curves coincide and cost rates double every 7-8 years.



Nothing that has been learned about the reasons for cost growth suggests that growth is non-linear. The change in depot maintenance process in FY00 argues for using data from FY00 through FY05. Therefore, the task force believes the linear projection using data from FY00 through FY05 provides the best estimate.

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APPENDIX V. OUTSOURCING SOME AERIAL REFUELING NEEDS

COMMERCIAL AIRCRAFT ARE MEETING SOME REFUELING REQUIREMENTS

The task force knew of the Navy's limited use of commercial assets for its aerial refueling needs and examined the feasibility of outsourcing tanking requirements on a larger scale. As noted in Chapter 3, emerging missions, such as homeland defense, could increase the demand for, and nature of, aerial refueling. The availability of commercial tankers to meet such requirements may be an attractive alternative, particularly in consideration of the inherent cost advantage. The use of commercial tankers may also enable the Air Force and Navy to meet more of the critical training requests that do not now compete well against higher priority requirements.

Omega Air, Inc. (Omega) briefed the Task force on their aerial refueling tanker, the tanking services they provide the Navy, and the potential to meet additional requirements. The Omega KC-707 is a FAA-certified aircraft, modified to a tanker configuration under a Supplemental Type Certificate. It has a hose and drogue system similar to that in use on KC-130 aircraft. Under contract to the Naval Air Systems Command, it was used successfully in 2002 and 2003 to support exercises, airwing workups, aircraft deployments, and general training. It clearly demonstrated the compatibility of commercial tanking with military training and deployment operations. The 2003 CNA study "Commercial Inflight Refueling" was very complimentary of the Omega KC-707 availability, reliability, flexibility, responsiveness, and, particularly, cost effectiveness. The report recommended the continued use of this service and the exploration "of using commercial tankers to decrease qualifications requirements with KC-10 and KC-135 tankers."

THERE ARE COST ADVANTAGES IN USING COMMERCIAL ASSETS

The cost advantage associated with the use of commercial assets derives mainly from substantially lower costs that are typically found in relatively small, lean commercial applications. The infrastructure and manpower tail associated with large-scale military activities is a significant cost driver that is largely absent in a small commercial activity. This provides a significant cost savings for the particular utilization. However, unless there is a commensurate reduction of assets on the military side, there are no net savings to DoD. The current tanking application simply meets an essential requirement (demonstrated by the Navy's willingness to pay) in a cost effective manner. To the extent that requirements grow due to homeland defense initiatives or due to a realization that additional training evolutions are hard requirements that must be met, the use of commercial assets can provide cost savings to DoD. Therefore, additional commercial outsourcing applications should be seriously considered.

There are several examples of successful commercial outsourcing of operational or training activities within DoD in addition to the Omega tanker contract. These include a variety of air assets that are used to provide services for the Navy and the Air Force throughout the world in the areas of electronic warfare (EW), air intercept control (AIC), aerial target towing, air to air combat training, and basic flight training evaluation. Examples include Learjets that carry threat simulator and jamming pods for EW training, provide tracking information for AIC services, and tow aerial targets; tactical aircraft, such as F-21 Kfir and F-35 Draken, that provide Dissimilar Air Combat Training; and the G-1 Gulfstream that provides EW standoff jamming and threat simulation and other electronic combat services.Should the Department desire to pursue commercial alternatives for certain tanking missions there are several options for sourcing aircraft. The homeland defense mission would, of course, be primarily conducted with aircraft equipped for boom tanking. As noted elsewhere in this report, the Royal Netherlands Air Force modified two aircraft to a tanker with boom configuration. The task force expects that a commercial entity could be encouraged to undertake a similar conversion program, given the opportunity for sufficient business to recover costs and turn a profit. Alternatively, the entity could utilize excess Air Force aircraft that are already boom equipped.

The efficacy of utilizing commercial assets to meet tanker requirements has been established. The task force recommends the DoD study this concept of operations for additional application, as it appears to have the capability to meet certain requirements at significantly lower cost.

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APPENDIX VI. GLOSSARY

DEFINITIONS, ACRONYMS, AND ABBREVIATIONS

DEFINITIONS

1-4-2-1	1-Defend the United States and Territories, 4- Deter forward in four critical regions, 2- Swiftly defeat the effort in overlapping major conflicts, 1- Upon the President's direction, win decisively one of the conflicts.

ACRONYMS AND ABBREVIATIONS

AoA	Analysis of Alternatives
ALC	Air Logistics Center
AMC	Air Mobility Command
CENTAF	U.S. Central Command Air Forces
CRAG	Compass, radar, and global positioning system
CONUS	Continental United States
DFAS	Defense Finance and Accounting Service
DISA	Defense Information Systems Agency
DoD	Department of Defense
DSB	Defense Science Board
ESLS	KC-135 Economic Service Life Study
FedEx	Federal Express Corporation
FY	Fiscal year
G&A	General and administrative
MNS	Mission Need Statement
MSR	Major structural repair
MTW	Major theater war
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
ORD	Operational Requirements Document
O&S	Operation and support

OSD (PA&E)	Office of the Secretary of Defense (Program Analysis and Evaluation)
PDM	Programmed depot maintenance
POM	Program Objective Memorandum
SIOP	Strategic Integrated Operations Plan
SPG	Strategic Planning Guidance
TRANSCOM	U.S. Transportation Command
TRS-05	Tanker Requirements Study 2005
UAV	Unmanned aerial vehicle
U.S.	United States
USAF	United States Air Force
USP	Unit sales price
WMD	Weapons of mass destruction