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Strategic Airlift Modernization: Analysis of C-5 Modernization and C-17 Acquisition Issues

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Summary

Strategic airlift has played a pivotal role in U.S. national security strategy since World War II. Since then, strategic airlift has provided timely worldwide reach for both combat and humanitarian relief operations. The Department of Defense (DOD) currently operates a mix of C-5 and C-17 aircraft. C-5s were built in two production batches, designated the C-5A and C-5B, respectively. A total of 52 C-5s are scheduled to undergo two major modification programs, after which they will be redesignated C-5M *Super Galaxies*; the remaining 59 C-5s will a major avionics upgrade. C-17s are currently in production, but the C-17 production line is scheduled to close unless additional orders are placed in an anticipated FY2008 supplemental appropriations bill.

A major issue currently before Congress is how big should the strategic airlift fleet be. There is a consensus among policy makers that the DOD must maintain a robust and effective strategic airlift fleet.

Currently, the most pressing issue is whether Congress should appropriate money for the purchase of more C-17s in anticipated FY2008 supplemental bills and, if so, for how many. A third potential issue is the optimal mix of C-5s and C-17s that Congress should fund in FY2009 and beyond. At least five options have been proposed for C-5 modernization and C-17 procurement including the following:

- Buy additional C-17s and pursue modernization of all C-5s.
- Halt C-17 production but modernize the current C-5 fleet.
- Maintain the C-5 fleet but forego modernization on all or part of the C-5 fleet while replacing the capability gap with C-17s.
- Replace all C-5A-models with new C-17s.
- Replace 30 C-5s with 30 C-17s.

Most agree the strategic airlift fleet should consist of a mix of C-17s and modified C-5s. Independent studies have analyzed policy options by attempting to measure long-term costs associated with various alternatives of C-5 modernization with C-17 acquisition. However, there remains disagreement over how many aircraft are required, and of what type. Policy considerations include costs, budget constraints, industrial base risk, aircraft performance considerations, and optimal fleet mix.

In addition to the aforementioned options, DOD could increase use of commercial aircraft, encourage foreign or civilian sales of the C-17, bolster reliance on pre-positioning of equipment, leverage potential KC-X airlift capability, pursue airships or hybrid airships, or simply accept less strategic airlift capability.

This report will be updated as events warrant.

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Introduction

The C-5 *Galaxy* and C-17 *Globemaster III* form the core of DOD's strategic airlift capability. Both posses intercontinental range and the ability to transport outsized[1] and oversized cargo.[2] The C-5 is the Air Force's largest strategic airlift aircraft and can carry some loads too large for any other DOD airlifter. In addition to its strategic airlift capabilities, the C-17 can perform the tactical airlift mission, which the C-5 cannot.

The Air Force's current plan is to extensively modernize a total of 52 C-5s, partially modernize 59 C-5s, and end C-17 production. This represents a departure from prior DOD plans that called for fully modernizing the Air Force's entire C-5 fleet and was part of changes announced when DOD re-certified one of the C-5's two major modification programs following high program costs growth.[3] The Administration did not request C-17s in either its FY2008 or FY2009 budget requests. Further, the Administration's FY2009 budget request did not contain funding to close the C-17 production line.[4] However, the Air Force's FY2009 Unfunded Priority List contained a request for 15 additional C-17s.[5]

The immediate issue for Congress is whether to appropriate funding for additional C-17 production in anticipated FY2008 war supplemental bills and, if so,

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[1] Outsized cargo exceeds the dimensions of oversized cargo and requires the use of a C-5 or C-17 aircraft or surface transportation. (Joint Publication 1-02, *DOD Dictionary of Military and Associated Terms*, amended through October 17, 2007, p. 401).

[2] Oversized cargo is air cargo that exceeds the dimensions of a standard (463L) pallet, but is air transportable on the C-5, C-17, C-130, KC-10, and most civilian contract cargo carriers. (Joint Publication 1-02, *DOD Dictionary of Military and Associated Terms*, amended through October 17, 2007, p. 402).

[3] Jen DiMascio, "Young Certifies C-5 Re-engining Program," *Defense Daily*, Vol. 237, Issue 31, February 15, 2008.

[4] Marc V. Schanz, "The C-17 and the Airlift Question," *Daily Report, Air Force Magazine*, February 6, 2008, on-line at [http://dailyreport.afa.org/AFA/Features/modernization/box020608airlift.htm].

[5] "FY2009 Unfunded Requirements List," U.S. Air Force, SAF/FMB, Budget and Appropriations Liaison Office, February 2008, p.2, on-line at [http://dailyreport.afa.org/NR/rdonlyres/BAD928B9-0927-4628-BE43-14992CB464C1/0/FY09URL.pdf].

for how many C-17s. Decisions made this year regarding force structure of the Air Force's strategic airlift fleet could significantly affect future U.S. military capabilities, Air Force funding requirements, and the aerospace industrial base.

Background

A central tenet of U.S. national military strategy is that strategic airlift is an essential capability enabling the military power projection anywhere around the world. Strategic airlift has proven critical in the success of global combat and humanitarian relief operations. An alternative transportation mode, sealift, is capable of deploying larger quantities of troops and cargo when compared with airlift, but it is slower and sometimes constrained by a lack of seaports near potential contingency operations. The capability that strategic airlift provides is the ability to deliver forces, equipment, and supplies with the greatest speed to virtually any place on the globe.

Despite its importance, DOD's strategic airlift system is under stress, having supported continuous contingency operations over the last 17 years. At the same time, the United States has reduced its Cold War infrastructure by closing two-thirds of its forward bases. Thus, U.S. forces are now required to deploy more frequently and over greater distances. For example, even before the 9/11 terrorist attacks and resulting conflicts, the Air Force estimated that it was deploying four times more frequently than when it enjoyed the larger Cold War infrastructure.[6] The ongoing war against terrorism has placed further demands on the strategic airlift system.

Combat Operations

The massive military buildup prior to the 1991 Gulf War highlighted the value of strategic airlift when U.S. aircraft moved over 500,000 troops and 543,548 tons of cargo into the Persian Gulf region.[7] After Desert Storm, strategic airlift provided 12 years of continuous support to coalition forces enforcing the northern and southern no-fly zones over Iraq. Since 1995, strategic airlift has also supported U.S. and NATO operations in the Balkans.

Strategic airlift plays a key role in combat operations in the Middle East. On a typical day, C-5s bring cargo and troops from the United States to staging bases in Europe, Central Asia, and the Middle East, while C-17s fly directly to forward operating bases in Iraq and Afghanistan. Since September 2001, over 260,000 airlift missions have delivered over 3.3 million passengers and 1.7 billion short tons of cargo to Iraq and Afghanistan.[8] Few nations possess the organic airlift capability necessary to project power around the world. Consequently, DOD's strategic airlift capability is often requisite to enabling coalition partners to join us in operations.

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[6] Maj. Gen. Howie Chandler, *Basic Air Force Structure and Expeditionary Aerospace Force Operations*, Briefing to Congressional Air Force Caucus, March 23, 2001, Bolling AFB.

[7] *Gulf War Air Power Survey*, vol. V, (Washington: GPO, 1993), p. 76.

[8] *The Air Force Handbook 2007*, pp 18-19.

As part of Operation Enduring Freedom in Afghanistan, nearly 170 C-5 and C-17 cargo planes were initially dispatched to create an "air bridge" to this distant, landlocked nation.[9] Although distance was clearly a challenge, securing permission for overflight and sourcing infrastructure appears to have been even more burdensome. Most Afghan airfields from which C-17s operated were short (~3,500 feet) and strewn with debris and potholes. Some airfields were nothing more than packed dirt, and C-5s cannot operate from these types of primitive airfields.[10] Two events from the Global War on Terrorism — the 2003 brigade airdrop and medical evacuation missions — reflect the evolving capabilities of strategic airlift.

Brigade Airdrop. Prior to Operation Iraqi Freedom, U.S. commanders expressed a desire to open a northern front during the invasion of Iraq. After the Turkish government denied the United States rights to stage the land invasion from Turkey, Air Force C-17s executed a much publicized airdrop of the 173rd Airborne Brigade into northern Iraq on March 26, 2003.[11]

Medical Evacuation. DOD retired its dedicated aeromedical evacuation fleet in 2003, switching to a concept where nearly every air mobility aircraft is capable of performing this time-critical mission. Strategic airlift platforms are now routinely tasked "in system" to perform patient movements. As a result, the time required to return a wounded service member from the battlefield is now approximately 72 hours — less than half that required for Desert Storm. This is contributing to survival rates for casualties in Afghanistan and Iraq now exceeding 90%, compared with 75% during Desert Storm.[12]

Humanitarian Relief Operations

Strategic airlift has proven its value many times since World War II by delivering humanitarian relief. During a 15-month stretch in 1948 and 1949, American and British airmen executed some 277,000 airlift sorties, keeping Berlin from being cut off from the West.[13] During the 1990s, more than 85% of some 160,000 metric tons of food, medicine, and relief supplies reached besieged Sarajevo, Bosnia-Herzegovina, via airlift.[14] More recently, strategic airlift delivered disaster relief after earthquakes in Iran (2003) and Pakistan (2005), the southeast Asia

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[9] Eric Schmitt, "Busy Skies Over Asia Controlled from U.S.," *New York Times*, October 14, 2001.

[10] Seena Simon, "Air Force Makes Play for More C-17s," *Air Force Times*, March 18, 2002, p. 26.

[11] Lt Col M. Shane Hershman, "Employment of the C-17 in Airdrop and Airland Operations in Closing the Force," March 18, 2005, pp. 6-7.

[12] Bruce D. Callander and Adam J. Hebert, "The 90 Percent Solution," *Air Force Magazine*, October 2006, vol. 89, no. 10, [http://www.afa.org/magazine/oct2006/1006solution.asp].

[13] Stewart M. Powell, "The Berlin Airlift," *Air Force Magazine,* June 98, vol. 81, no. 6.

[14] Louis A. Arana-Barradas (MSgt, USAF), "A 'Promise' of Peace," available at [http://www.af. mil/news/airman/0396/promise.htm].

tsunami (2004), and Hurricane Katrina (2005), demonstrating the importance of strategic airlift in mitigating consequences after natural disasters.[15]

Strategic Airlift Requirements

Strategic airlift requirements are ultimately derived from the President's overall national security strategy. Based on the President's strategy, DOD periodically studies the global threat environment and seeks to identify the military force structure necessary to meet national objectives, and articulates this analysis in the National Military Strategy (NMS) and Quadrennial Defense Review (QDR). Then, in the case of strategic airlift, DOD examines the status of its fleet and quantifies future airlift requirements to judge whether airlift modernization programs are sufficient to support DOD force structure and the President's strategy. In June 2004, DOD began its first "post 9/11" review of transportation requirements. The current Mobility Capability Study (MCS) was completed in December 2005 and briefed to Congress in February 2006.

Mobility Capability Study (MCS)

The unclassified executive summary of the MCS notes that unlike past mobility studies, the MCS did not recommend an airlift requirement expressed in million-ton-miles per day (MTM/D). Instead, the MCS assessed the capabilities of the current and projected force by providing a range of potential resource requirements for strategic airlift, intra-theater (tactical) airlift, and air refueling fleets. The MCS identified a need for between 292 and 383 strategic airlift aircraft. This assessment coincided with the Air Force's program of record at the time of 292 aircraft (180 C-17s and 112 C-5s with engine and avionics upgrades).[16] Thus, MCS recommended a strategic airlift force structure at the bottom of the range necessary to meet NMS requirements with "acceptable risk."[17] Subsequently, the 2006 QDR stated a DOD goal of maintaining 292 strategic airlifters.[18] To provide Congress with greater clarity into airlift requirements, the FY2007 Defense Authorization Act (P.L. 109-364, Sec. 1034) required DOD to submit a report to Congress no later than February 1, 2007, defining airlift requirements in terms of million-ton-miles per day. In response to this requirement, DOD delivered a classified report to the congressional defense committees on February 27, 2007.

The MCS findings surprised observers. Many expected the study to project a growth in airlift needs — perhaps a requirement closer to 60 MTM/D — from the previous estimate. The mobility study immediately prior to the MCS, the Mobility

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[15] USTRANSCOM Annual Command Reports, FY2002-2006, [http://www.transcom.mil].

[16] One C-5B was destroyed in a crash on April 3, 2006. See unattributed, "17 Airmen Survive Dover C-5 Crash," *Air Force Print News*, San Antonio, April 3, 2006, at [http://www.af.mil/news/story.asp?id=123018520].

[17] "Headquarters Air Mobility Command White Paper, KC-X: The Next Mobility Platform, The Need For A Flexible Tanker," p. 4.

[18] "Quadrennial Defense Review Report," February 6, 2006, p. 54.

Requirements Study 2005 (MRS-05), completed in 2000, set airlift requirements at 54.5 MTM/D.[19] Others speculated the MCS would not increase the 54.5 MTM/D requirement because planners knew that DOD could not afford to purchase enough aircraft to provide additional airlift.[20] They imply the MCS was not an unbiased study of requirements, but a compromise between what is needed and what can likely be afforded within current budget constraints.

Analysts also criticized the MCS for its methodology and focus. In September 2005, the Government Accountability Office (GAO) documented a number of shortcomings in methodology for the ongoing MCS.[21] A more detailed GAO criticism followed in September 2006 after the final MCS was released.[22] Others criticized the study for not adequately addressing DOD intra-theater airlift needs and for focusing on "near-term" capabilities rather than taking a longer view.[23] Criticism of the MCS with regard to intra-theater airlift requirements is particularly germane because the C-17 can be used in both the strategic and intra-theater roles. As a result, some believe DOD requires more C-17s to meet tactical requirements, even if strategic airlift requirements can be met with DOD's current programs of record.

In light of the criticism, some have called for DOD or an independent agency to conduct another mobility study to rectify the MCS's perceived shortcomings. In September 2006, it was reported that the Air Force's Air Mobility Command was again studying DOD airlift needs. Some may interpret the Air Force's initiation of another airlift study so soon after the completion of the MCS as tacit acknowledgment of flaws in the MCS and an attempt to ameliorate them.[24] Finally, two other significant issues have arisen since the MCS was released that may change strategic airlift requirements: the planned growth of the Army and Marine Corps by 92,000 additional troops and the potential airlift implications of the Army's ongoing transformation.

92,000 Additional Troops

On January 11, 2007, Secretary of Defense, Robert Gates announced a recommendation to the President to raise military end-strength by 65,000 Army

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[19] Marc Selinger, "DoD Launching New Review of Transportation Needs," *Aerospace Daily*, March 11, 2004.

[20] John Tirpak, "Air Mobility in the Doldrums," *Air Force Magazine*, vol. 88, issue 8, August 2005, at [http://www.afa.org/magazine/aug2005/0805mobility.html].

[21] *Defense Transportation: Opportunities Exist to Enhance the Credibility of the Current and Future Mobility Capabilities Studies*, Government Accountability Office, September, 2005.

[22] *Defense Transportation: Study Limitations Raise Questions About the Adequacy and Completeness of the Mobility Capabilities Study and Report*, GAO, September 2006.

[23] John T. Bennett, "Influential DoD Mobility Study's Focus on Intratheater Needs Questioned," *Inside the Air Force*, April 7, 2006.

[24] Michael Fabey, "AF Formulating Mobility Plan," *Aerospace Daily*, September 28, 2006.

soldiers and 27,000 Marines.[25] The President concurred with the recommendation, and bipartisan support was received for expanding active-duty end-strength by approximately 92,000 service members.[26] The adequacy of the Air Force's current and projected strategic airlift fleet to support these additional ground forces will need to be carefully evaluated. For example, if additional troops are used to form additional combat maneuver units, some in the Air Force reportedly believe it will take another 35 strategic airlift aircraft to support them.[27] In contrast, the placement of additional ground forces into support units of current combat maneuver units would require less additional airlift, as the number of maneuver units available for deployment would more closely parallel the force structure studied in the MCS.

Army Transformation

As yet unclear is the impact that the Army transformation will have on future requirements. A key facet of the Army plan is the Brigade Combat Team (BCT).[28] BCTs and future forces are being designed to be lighter and more easily air transportable. Therefore, the Army set a goal of obtaining the capability to deploy a "BCT anywhere in the world in 96 hours after liftoff, a division on the ground in 120 hours, and five divisions in theater in 30 days."[29] Although this organizational initiative may have merit, it is not clear that the current strategic airlift fleet will be able to meet these deployability targets. For example, a typical Stryker BCT consists of approximately 3,500 soldiers, 327 Stryker vehicles, 600 wheeled vehicles, field and air defense artillery, and engineering equipment. When considering the feasability of Army plans, a June 2003 GAO study found that "at present, it would take from five to 14 days, depending on brigade location and destination, and require over one third of the Air Force's C-17 and C-5 transport aircraft fleet to deploy one Stryker brigade by air."[30] Some might argue this illustrates a shortfall in strategic airlift capability. Others may point to pre-positioning and fast sealift as better methods to accelerate BCT deployment timelines. Further, some may propose a change in the composition of ground maneuver units to make them more deployable.

Future airlift requirements may also be affected by the Army's Future Combat System (FCS). A 2007 Defense Science Board (DSB) report cautioned increasing weights of FCS vehicles stating, "vehicles originally intended to weigh 17 to 18 tons

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[25] Robert M. Gates, Briefing by the Secretary of State, Secretary of Defense and Chairman of the Joint Chiefs of Staff, January 11, 2007.

[26] See CRS Report RL33999, *Defense: FY2008 Authorization and Appropriations*, by Stephen Daggett and Amy Belasco.

[27] John A. Tirpak, "The Air Force Starts Over: What Will it take to Get Some Stability into the Air Force Program?" *Air Force Magazine*, August 2007, vol. 90, no. 8, p. 36.

[28] BCTs have three organizational constructs: light infantry, armor, and Stryker. See CRS Report RL32476, *U.S. Army's Modular Redesign: Issues for Congress*, by Andrew Feickert.

[29] U.S. Department of the Army, *Concepts for the Objective Force*, 2001, p. 9.

[30] GAO Report to Congressional Committees, *Military Transformation: Realistic Deployment Timelines Needed for Stryker Brigades*, June 2003.

are now approaching 30 tons."[31] The additional weight could prove significant: FCS vehicles may become too heavy for C-130 tactical transports, leaving only strategic-sized airlifters capable of moving the FCS. Some have suggested that the Army use the C-17 as the "sizing template" for carrying future Army vehicles — this concept, if accepted, would almost certainly require more strategic airlift aircraft.[32]

Requirements Summary

How significant is the potential airlift shortfall, and does it jeopardize force projection capabilities? It may be difficult for Congress to evaluate DOD's airlift recapitalization plans because answers from DOD and independent studies are either dated, unclear, or classified. Questions include How much outsized/oversized airlift capacity is required, now that major state-on-state conventional warfare appears less likely, but still a contingency for which DOD must plan? How many aircraft are required now that irregular warfare — which can occur less predictably, and frequently in theaters with limited infrastructure — appears more likely? Will the standup of U.S. Africa Command result in additional strategic airlift requirements?

Legislative Initiative

Section 1046 of the 2008 National Defense Authorization Act directed DOD to conduct a comprehensive requirements-based study of fixed-wing airlift to include full-spectrum life-cycle costs of operating current and planned strategic airlift, tactical airlift, and air refueling fleets. Specifically, the legislation requires DOD to analyze the size and mix of the strategic airlift fleet while considering emerging requirements to transport new Army equipment such as the Future Combat System and leveraging new capabilities such as the anticipated airlift capability of future Air Force air refueling aircraft. Additionally, the study is expected to provide the Air Force with an opportunity to explain whether the estimated cost of C-5 RERP makes a RERP-modified C-5 fleet's life cycle costs higher when compared with alternative fleets with fewer C-5Ms and more C-17s. This study is required to forecast requirements for 2012, 2018, and 2024, respectively. DOD is required to submit the results of this study to Congress by January 10, 2009.[33]

Aircraft

The Air Force currently operates two strategic airlift aircraft: the C-5 *Galaxy* and the C-17 *Globemaster III*. Both are capable of being refueled in-flight. The C-5 is equipped with a nose section that opens, whereas both aircraft have rear-opening doors to facilitate rapid on-loading and offloading. Also, DOD utilizes air refueling aircraft and contract civilian carriers to provide additional strategic airlift.

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[31] DSB Task Force, "*Future Need for VTOL/STOL Aircraft*," July 2007, p. viii.

[32] General (Ret) Barry R. McCaffrey, Adjunct professor of International Affairs, Department of Social Sciences, United States Military Academy, West Point, NY, *After Action Report — Visit to Nellis and Scott AFB, 14-17 August 2007*, October 15, 2007, p. 4.

[33] H.Rept. 110-477, Section 1046, December 6, 2007, pp.313-316.

C-5 Galaxy

Made by Lockheed Martin, the C-5 is the largest strategic airlift platform in the DOD inventory. (C-5 specifications and basing appear in **Appendix A**.) The Air Force operates a total of 111 C-5s in the active, Air National Guard, and Reserve components. C-5s were built in two production batches, and aside from age, both models are interchangeable operationally. The first production aircraft were designated A-models, while later aircraft were designated as B-models. Two A-models were later modified to carry outsize cargo such as NASA rocket components and were redesignated C-models. The entire A/C-model fleet received new wings during the 1980s. In 2004, the Air Force retired 14 A-model C-5s.[34] **Table 1** highlights key factors of the C-5 fleet.

Table 1. Current C-5 Fleet

	C-5A/C	C-5B
Current Inventory	60/2	49
# Produced	81	50
Years Built	1969-73	1985-89

Source: Teal Group Corporation, *World Military & Civil Aircraft Briefing*, September 2006.

All C-5s can carry large and irregularly shaped cargo, such as the Army's 74-ton mobile scissors bridge, that no other U.S. aircraft can hold. However, the C-5 has been plagued by reliability problems. FY2005-FY2007 data show C-5 mission capable rates of only 48% for C-5A/C and 65% for the C-5B. To address reliability issues, the Air Force proposed two major modification programs designed to bring C-5 mission capable rates to a goal of 75% — the Avionics Modernization Program (AMP) and the Reliability Enhancement Re-engining Program (RERP). After completing these two programs, C-5s will be designated C-5M *Super Galaxies*.

Avionics Modernization Program (AMP). AMP is a $1.4 billion project to upgrade C-5 communications, navigation, and air traffic control surveillance components.[35] AMP is intended to ensure C-5s comply with emerging air traffic management requirements, allowing C-5s to fly in global airspace without restrictions. Operational testing of AMP was completed in 2006, and the last of the 111 C-5s planned for upgrade is scheduled to be complete by the end of 2014. As

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[34] Susan H. H. Young, "Gallery of USAF Weapons: 2007 USAF Almanac," *Air Force Magazine*, May 2007, p. 146.

[35] Selected Acquisition Report, C-5 AMP, December 31, 2006, p. 9, from Defense Acquisition Management Information Retrieval. Cost is shown in 2006 This Year dollars and includes $409.4 million for Research, Development, Test and Evaluation.

of September 2007, 30 C-5s had completed AMP modification, which establishes the digital baseline for follow-on components to be installed under RERP.[36]

Reliability Enhancement Re-engining Program (RERP). RERP is a reportedly $7.7 billion[37] comprehensive modernization plan with more than 70 initiatives to upgrade major C-5 systems.[38] The goal of RERP is to improve availability, reliability, and maintainability of the C-5. The centerpiece of RERP is replacing C-5 engines with modern General Electric CF6 engines. The Air Force's current plan is to modernize a total of 52 C-5s with the RERP — all 49 C-5Bs, 2 C-5Cs, and 1 C-5A. This represents a departure from prior DOD plans that called for fully modernizing the Air Force's entire C-5 fleet.[39] The program change was announced when DOD re-certified the C-5 RERP following costs growth for the previous 111-aircraft program reaching $17.5 billion.[40]

Air Force officials expect the C-5M (C-5s modernized through both AMP and RERP) to bolster the strategic airlift capability by making more of the C-5 fleet available on a daily basis. For example, they expect to improve C-5 mission-capable rates from the low 50% range today to at least 76% in the future. In addition, the C-5M is expected to possess operational improvements that will require 30% less takeoff distance, while enabling the *Super Galaxy* to reach cruise altitude 58% faster that current C-5s. Finally, the C-5M is anticipated to be more environmentally friendly by creating less noise and fewer carbon emissions.[41] Currently, three C-5s have been modified with RERP — one A-model and two B-models — and are undergoing operational testing.[42]

Retirement Restrictions. The FY2004 Defense Authorization Act (P.L. 108-136, Sec. 132) prohibited the retirement of C-5A aircraft until the effectiveness of the C-5A AMP and RERP efforts has been determined through testing and

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[36] The Honorable Sue C. Payton, Assistant Secretary of the Air Force (Acquisition), Written Statement before the Senate Homeland Security and Governmental Affairs Committee, Federal Financial Management, Government Information, Federal Services, and International Security Subcommittee Hearing, September 27, 2007, pp. 3-4.

[37] "Lockheed Deal Scaled Back," *Washington Post*, February 15, 2008, p.D2.

[38] Selected Acquisition Report, C-5 RERP, September 30, 2007, p. 9, from Defense Acquisition Management Information Retrieval. Cost is shown in 2007 This Year dollars and includes $1,657.2 million for Research, Development, Test and Evaluation.

[39] Jen DiMascio, "Young Certifies C-5 Re-engining Program," *Defense Daily*, Vol. 237, Issue 31, February 15, 2008.

[40] "Lockheed Deal Scaled Back," *Washington Post*, February 15, 2008, p.D2.

[41] Hearing of the Senate Homeland Security and Governmental Affairs Committee, Federal Financial Management, Government Information, Federal Services, and International Security Subcommittee on Military Airlift Costs, September 27, 2007. Other sources cite a 75% target mission capable rate.

[42] The Honorable Sue C. Payton, Assistant Secretary of the Air Force (Acquisition), Written Statement before the Senate Homeland Security and Governmental Affairs Committee, Federal Financial Management, Government Information, Federal Services, and International Security Subcommittee Hearing, September 27, 2007, p. 4.

evaluation and reported to Congress. As such, the Air Force modified one C-5A through both AMP and RERP and is currently conducting operational testing on the aircraft. In 2007, Congress amended this restriction, allowing the Air Force to retire strategic airlifters beginning October 1, 2008, as long as the Air Force maintains a strategic airlift fleet of at least 299 aircraft — seven aircraft above the MCS baseline.[43]

"Bad Actors." During deliberations on the FY2008 budget request, Air Force leaders frequently requested permission to retire some C-5A aircraft independent of the test results on C-5A RERP and AMP. To support their request, Secretary of the Air Force, Michael W. Wynne, and Air Force Chief of Staff, General T. Michael "Buzz" Moseley, testified that some subset of the C-5A fleet is composed of "bad actors," aircraft that are "hard broke" and are prime candidates for early retirement.

> GEN. MOSELEY: In a perfect world, we would like to be able to manage that inventory and divest ourselves of the bad-acting tail numbers, and some of them are bad actors; they're broke. A lot of the C-5As have low flight hours on them because they're broke and you can't fly them.... If I could line up the best B model or the best A model at the head of a line ... and go to the back end of the line and begin to kill off the bad actors and replace them with something new, I would be very happy. That doesn't mean all of them; it doesn't mean that we class or block-retire airplanes, it just means let us get at the tail numbers that are bad actors.[44]
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> SEC. WYNNE: There's some that are really bad actors. And I think if you gave us the right to manage the fleet, you would find that we would manage it in a way that would actually retain the best mission profiles....[45]
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> SEC. WYNNE: I can tell you, sir, that right now some worry about the entirety of the C-5 fleet. There are two things we should know about this. First is that we don't — we want to line up worst to best, and we think there are between 20, 25 and 30 of bad actors that we would like to retire.[46]

Some in Congress appeared supportive of Secretary Wynne's and General Moseley's "bad actor" testimony and requested the Air Force provide a list of these "hard broke" aircraft, presumably to make a judgement on whether these aircraft should indeed be retired early.[47] Others responded with skepticism, concerned that

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[43] P.L. 110-107, 10 U.S.C. 807, Sec. 8062.

[44] Hearing of the House Armed Services Committee on Fiscal Year 2008 National Defense Budget Request From the Department of the Air Force, February 28, 2007, 2118 Rayburn House Office Building, Congressional Transcript, Federal News Service, Inc.

[45] Ibid.

[46] Hearing on the Senate Armed Services Committee on Air Force Authorization Request for Fiscal Year 2008 and the Future Years Defense Program, March 20, 2007, 325 Russell Senate Office Building, Congressional Transcript, Federal News Service, Inc.

[47] See, for example, dialogue between Reps. Marshall and Saxton and Lt. Gen. Carol "Howie" Chandler. Hearing of the Air and Land Forces Subcommittee of the House Armed

(continued...)

Congress has not received "factual data" on the health and performance of the C-5A fleet.

During a September 2007 Senate hearing, both Ms. Sue Payton, Assistant Secretary of the Air Force for Acquisition, and General Schwartz, Commander of U.S. Transportation Command, stated that they were unaware of specific "bad actor" C-5 aircraft.[48] Further, an examination of C-5 reliability and maintainability statistics for the past three fiscal years did not identify any obvious subset of the C-5 fleet that stands out as notably "bad actors." Reliability and availability measures studied included the amount of time spent in a depot or otherwise unavailable because of maintenance, mission capable rate, and mission departure reliability. (Graphic representation of data and analysis can be found in **Appendix C**.)

Some might argue all C-5As could be considered bad actors. While the C-5A may have many hours of life remaining, it is an older aircraft than the C-17. However, the Air Force's Fleet Viability Board found the C-5A fleet — with appropriate investments — has at least 25 years of life remaining.[49] In addition, the Defense Science Board and the Institute for Defense Analysis have also endorsed the viability of the C-5A fleet. Further, C-5A performance and reliability are not uniformly inferior to the C-5B. Over the past three years, for example, the C-5A fleet has averaged a marginally higher mission departure reliability rate (83.1%) than the C-5B fleet (81.3%). This data may lead one to conclude that C-5A mission capable rates lag behind those of the C-5B because of management decisions rather than aging aircraft maintenance issues.

In the summer of 2007, two C-5A aircraft were restricted from flight, and 12 were load-restricted or flight profile-restricted, because of a variety of maintenance or repair issues. Some suggest these 14 aircraft are appropriate candidates for early retirement. In contrast, others cite that it is estimated to cost only $26.7 million to repair all 14 aircraft. In addition, 8 of the 14 restricted aircraft required routine modifications to address human-error damage incurred during routine maintenance. Arguably, these problems are minor and easily addressed, and do not warrant early retirement. While this counter-argument appears sound, it also speaks to the value of conducting robust analysis of an aircraft's maintenance and performance history and projected future costs and challenges. A single-point snapshot of an aircraft's condition can be an incomplete and misleading description of its health, and, by itself, a poor basis for retirement decisions.

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[47] (...continued)
Services Committee on Air Force and Army Airlift and Aerial Refueling Fixed-Wing Aircraft Programs, March 7, 2007, 2118 Rayburn House Office Building, Congressional Transcript, Federal News Service, Inc.

[48] Hearing of the Senate Homeland Security and Governmental Affairs Committee, Federal Financial Management, Government Information, Federal Services, and International Security Subcommittee on Military Airlift Costs, September 27, 2007.

[49] Tech. Sgt. David A. Jablonski, "Air Force Fleet Viability Board releases C-5A Assessment," *Air Force Print News*, July 15, 2004, and Amy Butler, "With a Little Help — And Cash — C-5As Can Fly For 25 More Years, Panel Says," *Defense Daily*, July 19, 2004.

C-17 *Globemaster III*[50]

Made by Boeing, the C-17 is DOD's most modern strategic airlifter. (C-17 specifications and basing are located in **Appendix A**.) Because it can use short and unfinished runways and has high maneuverability on the ground, the C-17 can operate in environments traditionally confined to smaller airlifters. Thus, C-17s can often deliver payloads from the United States directly to forward bases near the battle. Like C-5s, C-17s can carry outsize and oversize cargo such as helicopters and missile launchers.

Current DOD plans call for the acquisition of 190 C-17s. The Administration did not request additional C-17s in either its FY2008 or FY2009 budget requests. Further, the Administration's FY2009 budget request did not contain funding to close the C-17 production line.[51] However, the Air Force's FY2009 Unfunded Priority List contained a request for $3.9 billion to fund 15 additional C-17s.[52]

The C-17 is also capable of performing tactical airlift missions. During Operation Allied Force, the Kosovo Campaign in 1999, 12 C-17s were tasked to fly intra-theater airlift missions moving 24 Apache helicopters, 36 Abrams tanks, and 58 Bradley fighting vehicles from bases within Europe to Tirana, Albania.[53] Likewise, the C-17 has been used extensively in a tactical role in both Afghanistan and Iraq. In the summer of 2006, the Air Force forward-deployed two squadrons of C-17s. In addition to connecting southwest Asia mobility hubs with mobility hubs in Europe, these two squadrons have been used extensively in both Afghanistan and Iraq.

Convoy Relief. In late 2004, military commanders increased intra-theater airlift capability to reduce the number of ground convoys exposed to ambush in Iraq and Afghanistan. C-17s were tasked to transition to the tactical airlift role along side C-130s to perform this mission.[54] The reported effect of increased tactical airlift has been to "relieve nearly 3,500 vehicles and 9,000 convoy operators per month from having to travel treacherous Iraqi and Afghan roads."[55]

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[50] See CRS Report RS22763, *Military Airlift: C-17 Program Background*, by William Knight and Christopher Bolkcom.

[51] Marc V. Schanz, "The C-17 and the Airlift Question," *Daily Report, Air Force Magazine*, February 6, 2008, on-line at [http://dailyreport.afa.org/AFA/Features/modernization/box020608airlift.htm].

[52] "FY2009 Unfunded Requirements List," U.S. Air Force, SAF/FMB, Budget and Appropriations Liaison Office, February 2008, p.2, on-line at [http://dailyreport.afa.org/NR/rdonlyres/BAD928B9-0927-4628-BE43-14992CB464C1/0/FY09URL.pdf].

[53] Lt Gen William J. Begert, USAF, "Kosovo and Theater Air Mobility," *Aerospace Power Journal*, Winter 1999.

[54] TSgt Don Nelson, "Increased C-130, C-17 Flights Relieve Army Ground Convoys," Air Force Print News, December 15, 2004, [http://www.globalsecurity.org/military/library/news/2004/12/mil-041215-afpn04.htm].

[55] Gen T. Michael Moseley, USAF, "CSAF's Vector: Air Mobility's Strategic Impact," May

(continued...)

Precision Airdrop. Enabling coalition ground forces operating in the rugged mountains of Afghanistan, C-17s are using the Joint Precision Airdrop System (JPADS) to airdrop supplies with GPS-guided steerable parachutes. JPADS allows the resupply of field units with a high degree of accuracy helping ground forces receive supplies while avoiding the exposure of larger, traditional drop zones. Also, airdrops can be flown from high altitude, increasing safety margins to airlift aircraft.[56]

Policy Considerations

In addition to strategic airlift requirements, additional factors to consider regarding the future strategic airlift fleet include the following:

- Costs.
- Budget Constraints.
- Industrial Base Risk.
- Aircraft Performance.
- Optimal Fleet Mix.

Costs

Making an "apples-to-apples" comparison of C-5 and C-17 costs is complicated. The scope and time frame considered (e.g., flyaway cost, procurement cost, life-cycle cost), rate of production assumed, and procurement approach used (e.g., multi-year, annual, or supplemental procurement) all affect comparisons. For example, it is estimated 10 C-17s procured via annual congressional earmark cost approximately $20 million more per aircraft than C-17s procured via multiyear contracts.[57] Consequently, some may question whether it is appropriate to compare these costs to those incurred by acquisitions included in annual Air Force budgets. **Table 2** summarizes some factors to consider when comparing costs of C-5 modernization with C-17 procurement.

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[55] (...continued)
23, 2007, [http://www.af.mil/library/viewpoints/csaf.asp?id=324].

[56] Air Mobility Command Public Affairs, "C-17 Employs "Screamer" in Combat Airdrop," May 25, 2007, [http://www.af.mil/news/story.asp?id=123054785].

[57] Conversation between SAF/AQQ and CRS, September 21, 2007.

Table 2. C-5 Modernization vs. C-17 Procurement

	Modernize C-5 Fleet	Buy More C-17s
Average Procurement Unit Cost[a]	$146.7 Million[b]	$280 Million
Estimated Flying Hour Cost[c]	$23,075[d]	$11,330
Production Rate	~12 aircraft/ year	~15 aircraft/year
Aircraft Flying Hours Remaining	26,000 hours	30,000 hours

a. Selected Acquisition Report (SAR) Department of Defense OUSD (AT&L). Defense Acquisition Management Information Retrieval (DAMIR). C-17A, C-5AMP, C-5RERP.

b. These costs have and will likely fluctuate over time. The procurement cost of future C-17s will likely be lower than the average, as learning increases and fixed costs are amortized over a longer production run.

c. Aircraft Reimbursement Rates (per Flying Hour) FY2007. Air Force Cost Analysis Agency, Cost Factors Branch. Table A15-1.

d. Aircraft Reimbursable Rates (per Flying Hour) reflect amortization of modernization programs, but not procurement costs. Because the C-5 AMP and RERP modernization programs are in their early phases, these costs strongly affect the hourly cost to operate the C-5. The C-17 is not implementing a modernization plans on the scale of AMP and RERP.

Institute for Defense Analysis (IDA) Study. The Air Force's decision to modernize all C-5 aircraft was informed by a March 2000 Institute of Defense Analysis (IDA) study on the cost and reliability implications of various C-17 and C-5 force structure options. The idea of modernizing the C-5 to achieve improved availability gained support in 1996 when the Air Force asked Lockheed Martin to submit proposals to bring C-5 performance in-line with other air mobility assets. In 1997, IDA validated that the concepts proposed by Lockheed Martin could be cost effective if near-term dollars were available to fund the modernization program.[58] IDA noted that earlier studies indicated:

> Upgrading the C-5 may be cost-effective if the C-5 is to be retained in the fleet long enough, the larger question of whether money spent for improving strategic airlift should be directed toward C-5 improvements or toward some other improvements, such as adding more C-17s, or even some of both, is an issue.[59]

IDA measured the life-cycle cost (LCC) of nine alternatives for C-5 modernization and C-17. Findings are summarized in **Table 3**. However, at least three assumptions have changed since the IDA study was published, causing some to question the validity of the now seven-year-old study:

- Analysis was based on C-17 procurement of 135 aircraft, compared with the 190-aircraft program of record today.[60]

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[58] *Analysis of Alternatives for Out- and Over-Size Strategic Airlift: Reliability and Cost Analyses*, Institute for Defense Analyses, IDA Paper P-3500, March 2000, pp. 1-2.

[59] Ibid., p. 1.

[60] Ibid., p. 3.

- Analysis was based on modernization of the Air Force's 126-aircraft C-5 fleet, compared with the current 111-aircraft C-5 fleet today.[61]

- IDA calculated a $5.7 billion cost for RERP.[62] Using the 2.9% discount rate IDA used in the study, this translates to a 2007 cost of $6.96 billion — significantly below the December 2006 Selective Acquisition Report (SAR) cost of $17.5 billion.[63]

Table 3. Life-Cycle Cost (LCC) Estimates of Potential Alternatives to Modernizing the Strategic Airlift Fleet

Alternative	MTM/D	C-5A RERP upgrade	C-5B RERP upgrade	# of C-17s	LCC Constant $B	LCC Discounted $B	LCC Then-year $B
1	24.9	No	No	135	60.5	32.9	98.5
2	27.1	No	No	155	72.4	40.8	115.5
3	30.1	No	No	180	87.3	50.4	137.0
4	27.8	No	Yes	155	70.2	40.4	110.6
5	30.7	No	Yes	180	85.1	50.0	132.1
6	27.2	Yes	Yes	135	56.7	32.5	89.5
7	32.3	Yes	Yes	180	83.5	50.0	127.9
8	27.7	Retired	Yes	210	80.2	49.0	120.9
9	27.9	Retired	Retired	257	88.3	55.4	129.3

Source: IDA Paper P-3500, March 2000. Tables 2 and 3 combined and adapted by CRS.

Notes: All cost estimates expressed in $FY2000. Constant dollars allow comparisons over different time periods without inflation. Discounted dollars are adjusted to account for the year in which funds are expended. OMB discount factor of 2.9% per year used. Then-year dollars represent the estimated actual outlay of funds through 2040, including inflation. MTM/D = million-ton-miles per day.

IDA found "... the least costly option was Alternative 6, a full upgrade to the C-5 fleet with no additional C-17s," and that "... the $5 billion required for the upgrades in Alternative 6 more than pays for itself in reduced operating costs over the 40-year period examined."[64] Skeptics might contend that Alternative 6 is no longer a viable option because Congress has already funded a C-17 fleet of 190 aircraft. While some may question whether IDA's study is still valid, others believe it is still relevant to C-5 modernization and C-17 procurement decisions. For example, a comparison of Alternatives 1 and 6 reveals the cost of a re-engined C-5

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[61] Ibid., p. 6.

[62] Ibid., p. 44.

[63] Selected Acquisition Report, C-5 RERP, September 30, 2007, p. 9, from Defense Acquisition Management Information Retrieval. Cost is shown in 2007 This Year dollars.

[64] *Analysis of Alternatives for Out- and Over-Size Strategic Airlift: Reliability and Cost Analyses*, Institute for Defense Analyses, IDA Paper P-3500, March 2000, p. 11.

fleet may be lower than one without re-engining while also providing a higher MTM/D capacity. In addition, a comparison of Alternatives 3, 5, and 7 — the alternatives that most closely approximate DOD's current program of record — indicates that modernization of all C-5s maybe more cost effective and provide more capability than modernizing no C-5s or only the C-5B fleets.

Rand Study. In 2005, the Rand Corporation completed a study proposing a model to inform decisions about modernizing aging aircraft and procuring replacements. The study specifically compared C-5A RERP with C-17 procurement using the Air Force's Total Ownership Cost as a measure. Like IDA's study, some may criticize Rand's analysis for underestimating the cost of RERP by using a cost of $75 million per RERP-modernized C-5A — approximately $18 million per RERP-modernized aircraft below estimates found in the Air Force's December 2006 SAR after adjusting with a discount factor of 2.9% per year. Second, the study was unable to fully isolate C-5A cost factors from those of the C-5B. This could be problematic if younger B-models masked higher operating costs potentially associated with flying older A-models. As a result, the study's authors viewed their "findings as illustrative and suggestive, rather than definitive, particularly in light of concerns with" C-5A cost parameters utilized in the study.[65]

Rand's study found for C-5A RERP to cost less than new C-17s, RERP would have to start prior to 2015. To some, this indicates beginning C-5A RERP earlier makes the program more attractive than C-17 acquisition. When the first C-5A begins RERP upgrade in 2014, the youngest A-model will be 41-years old.[66] In 2004, former commander of U.S. Transportation Command, General John Handy, stated, "by 2012 it may be that the whole notion (of performing the RERP on the C-5As) is overcome by events." The A-models, he said, might be too far gone to be worth the investment.[67] Rand's study also suggested the number of C-17s required to replace C-5As was a second key consideration. Results indicated if 70 or more C-17s were required to replace the C-5A fleet, then RERP becomes the lower-cost option.[68]

RERP Cost Growth. In 2007, Air Force officials began to express concern about anticipated significant C-5 RERP cost growth. As late as December 2006, the SAR for the C-5 RERP showed average procurement unit cost growth of 2.9% over the current acquisition program baseline and 16% over the original baseline. This rate of cost growth is significantly lower than 15% and 30% cost growth,

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[65] Edward G. Keating, Don Snyder, Matthew Dixon, and Elvira N. Loredo, Rand Corporation Project Air Force, *Aging Aircraft Repair-Replacement Decisions with Depot-Level Capacity as a Policy Choice Variable,* Santa Monica, CA, 2005, pp. xii-xiii.

[66] Selected Acquisition Report, C-5 RERP, September 30, 2007, p. 12, from Defense Acquisition Management Information Retrieval.

[67] John A. Tirpak, "Saving the Galaxy," *Air Force Magazine,* January 2004, pp. 31-35.

[68] Edward G. Keating, Don Snyder, Matthew Dixon, and Elvira N. Loredo, Rand Corporation Project Air Force, *Aging Aircraft Repair-Replacement Decisions with Depot-Level Capacity as a Policy Choice Variable,* Santa Monica, CA, 2005, p. xiii.

respectively, required to trigger a Nunn-McCurdy breech notification.[69] In September 2007, the Air Force declared C-5 RERP had breached Nunn-McCurdy thresholds. The September 2007 SAR followed, showing a cost increase of approximately $6 billion and estimating RERP will now cost a total of $17.5 billion.[70]

Unfortunately, the Air Force and Lockheed Martin were far apart on cost estimates for C-5 RERP. Lockheed Martin has submitted a combination firm-fixed price (FFP)/not-to-exceed (NTE) contract offer for approximately $11.6 billion dollars.[71] Further, many contributing factors to RERP cost growth reported in the SAR appeared to be one-time management problems that may not affect future costs. For example, a permanent waiver to the Berry Amendment[72] would allow the Air Force to proceed with purchase of new General Electric engines that are built in part with imported specialty metals.[73] The impact of other factors affecting cost growth has proven more difficult to reconcile.

In testimony before a Senate subcommittee, Lockheed Martin and the Air Force explained their perspectives on cost growth. Ms. Payton, Assistant Secretary of the Air Force for Acquisition, testified that the C-5's AMP upgrade, a prerequisite the RERP, has taken longer than anticipated, because the Air Force has encountered unexpected repairs on its aging C-5s during the modification process. In addition, Ms. Payton expressed concern that the Air Force could not commit to a long-term schedule that might form the basis of a FFP contract, noting uncertainty with legacy maintenance issues and hard-to-predict wartime requirements. Under FFP contracts, some changes in quantity could serve to reopen contract negotiations leading to increased program costs. The Air Force believes this risk alone could drive engine costs up by as much as $10 million per airplane in future years. In addition, the Air Force believes that Lockheed Martin cost estimates for hands-on or touch labor are overly optimistic. Further, the Air Force's cost position accounts for anticipated legacy aircraft repairs that are likely to be discovered during RERP production.[74]

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[69] The Nunn-McCurdy Amendment was designed to curtail cost growth in defense procurement programs. When a program exceeds the Nunn-McCurdy thresholds for cost growth, the service secretary must notify Congress, and the Secretary of Defense must (1) either cancel the program or certify that it remains essential to national defense, (2) certify that the program is the least cost alternative available, and (3) ensure that proper management controls are in place.

[70] Selected Acquisition Report, C-5 RERP, September 30, 2007, p. 19, from Defense Acquisition Management Information Retrieval.

[71] Michael Sirak, "*Payton: Air Force Expects First C-5 RERP Contract in Early 2008,*" Defense Daily, vol. 236, issue 1, October 1, 2007.

[72] For more on the Berry Amendment, see CRS Report RL31236, *The Berry Amendment: Requiring Defense Procurement to Come from Domestic Sources*, and CRS Report RL33751, *The Specialty Metal Clause in the Berry Amendment: Issues for Congress*, both by Valerie Bailey Grasso.

[73] Selected Acquisition Report, C-5 RERP, December 31, 2006, p. 4, from Defense Acquisition Management Information Retrieval.

[74] Senate Homeland Security and Governmental Affairs Committee, Federal Financial (continued...)

While testifying, Larry McQuien, Vice President of Business Ventures for Lockheed Martin Aeronautics, acknowledged Lockheed Martin's cost proposal did not include costs for "training, spares, support equipment, over and above aircraft maintenance, and program management."[75] However, he stated confidence in estimates for engine costs and cited production changes that would eliminate about 19,600 hours in touch labor.[76] Lockheed Martin argues that if its cost estimates are proven correct, the RERP program will grow at rates below the Nunn-McCurdy threshold notification requirement.[77] **Table 4** provides Lockheed Martin's estimates of various production schedules.

Table 4. RERP Production Schedules and Cost Growth

FY	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	Total ($B)
PB 03	5	7	12	12	12	12	12	12	12	12						8.7
PB 06	1	3	5	7	9	12	12	12	12	12	12	12				8.9
PB 08		1	3	9	10	10	10	12	12	13	13	12	2			9.8
LM		1	3	5	7	10	10	10	12	12	13	13	12			11.6
USAF 01/07		1	3	6	7	7	7	7	7	7	7	12	12	12	13	14.9

Source: Lockheed Martin Aeronautics Company, September 10, 2007.

Note: PB = President's Budget, LM = Lockheed Martin, USAF = U.S. Air Force.

In Febraury 2008, Undersecretary of Defense for Acquisition, Technology, and Logistics, John Young, re-certified the C-5 RERP, but with changes. Under the new program, the Air Force can contract with Lockheed Martin to perform RERP modifications to the remaining 47 C-5Bs and 2 C-5Cs. DOD officials expect the changes to save $9.8 billion by foregoing the RERP on 59 older C-5As.[78]

Legislative Direction. The 2008 National Defense Authorization Act directed the Air Force to identify options for accelerating the C-5 RERP operational testing. Congress also directed DOD to task IDA to perform an objective analysis

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[74] (...continued)
Management, Government Information, Federal Services, and International Security Subcommittee Hearing on Military Airlift Costs, September 27, 2007.

[75] Ibid.

[76] Ibid.

[77] *White Paper on C-5 Reliability Enhancement and Re-Engining Program (RERP) Costs*, Lockheed Martin Corp, [undated], e-mailed to CRS on April 27, 2007.

[78] Andrea Shalai-Esa, "Pentagon Slashes Lockheed's C-5 Upgrade Work," *Reuters*, February 14, 2008.

of the Air Force's cost position regarding the C-5 RERP and to forward the review to congressional defense committees by March 1, 2008.[79]

Budget

Both the IDA and Rand studies suggested life cycle costs savings favor C-5 RERP performed sooner rather than later by providing a longer period for the Air Force to recoup its up-front investment. Likewise, testimony by both Lockheed Martin and the Air Force suggests that a predictable schedule, although difficult to achieve, is potentially a critical element to keeping program costs down over time. The most efficient rate of RERP production is 12 aircraft per year. Obtaining and sustaining this production rate over a longer period could save $6 billion, when comparing the President's Budget from 2003 and most recent Air Force RERP profiles.[80] The challenge of achieving this schedule appears to be primarily budgetary. Some assert that more money will be required in the Air Force's air mobility account during the Future Years Defense Plan (FYDP) than currently exists to keep C-5A modernization LCC below the LCC for C-17 acquisition.

Proponents of C-17 acquisition have suggested that retiring some C-5s early could make funds available for additional C-17s. However, these funds do not "line up" in the DOD budget. C-5 RERP procurement funds for FY2008 are only $253 million — just less than the cost of a single C-17. C-5 RERP funds in FY2009 are $540 million — approximately the cost of two C-17s. Significant C-5 RERP funds are not projected to be available until the end of the FYDP, and continued C-17 production is an FY2008 issue, given the imminent closure of the C-17 production line. Therefore, if more C-17s are to be purchased in FY2008, room would need to be found in the Air Force's "base budget," or Congress would need to add funds to DOD's FY2008 Global War on Terror (GWOT) funding request.

Figure 1 highlights how defense appropriations exempted from budget caps (including "bridge funds" for overseas operations provided as separate titles in the regular defense appropriations bills) have grown considerably in recent years, in both absolute terms and as a proportion of overall defense spending. According to some, this growth

> reflects a progressive expansion of the kinds of equipment and operational support that both the Defense Department and Congress have agreed to consider as sufficiently urgent to warrant inclusion in emergency funding measures, even though the funding may not meet definitions either of the narrowly defined incremental costs of military operations, or of what constitutes an emergency by congressional standards.[81]

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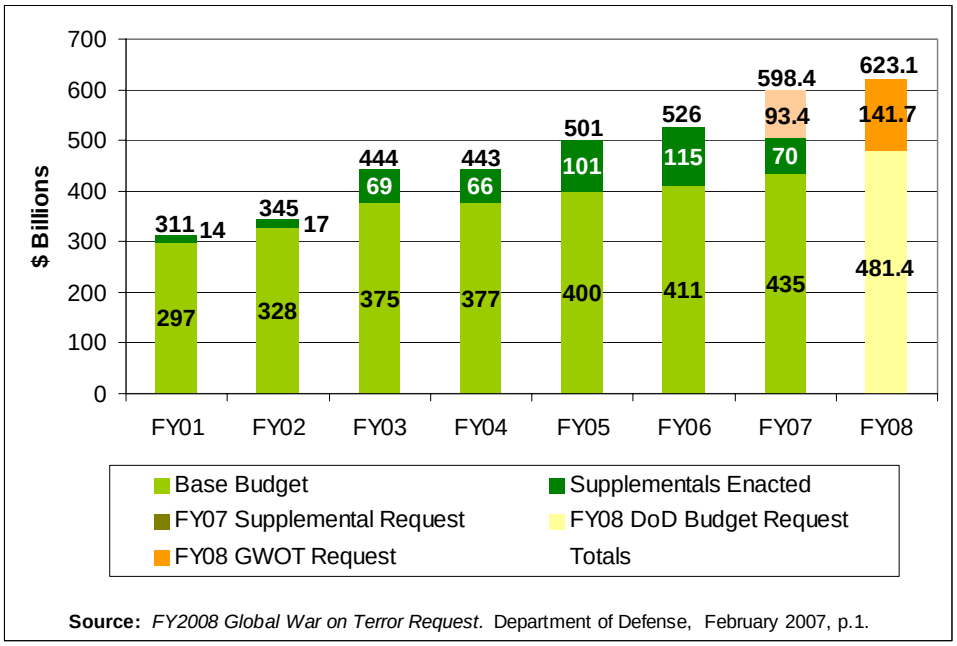
[79] H.Rept. 110-477, December 6, 2007, pp.746-747.

[80] Factors other than production rate may affect costs, making the degree of causality uncertain.

[81] CRS Report RL33900, *FY2007 Supplemental Appropriations for Defense, Foreign Affairs, and Other Purposes*, by Stephen Daggett, Amy Belasco, Pat Towell, Susan B. Epstein, Connie Veillette, Curt Tarnoff, Rhoda Margesson, and Bart Elias.

Figure 1. DOD Base Budget and GWOT



Source: *FY2008 Global War on Terror Request*. Department of Defense, February 2007, p.1.

Decisions to add funds to DOD's FY2008 GWOT request for C-17s are likely to be influenced by a wider debate on whether some of the large increase in weapons procurement requested in the past supplemental appropriation bills goes beyond the expanded definition of war-related requirements that some have come to accept. Those opposed to expanded use of emergency supplementals may argue adding funds to the FY2008 GWOT request is inappropriate because the rationale for doing so is not related to the immediate conflict. Instead, the arguments proffered by the Air Force pertain to long-term savings. Those in favor of expanded use of supplemental appropriations may point to congressional action in the FY2007 supplemental, where Congress provided over $1 billion more than requested for DOD procurement.

C-17 Production Line and Risk

The C-17 production line is scheduled to close without additional DOD orders for FY2008. Arguments for continued C-17 production often revolve around the concept of risk. Questions commonly asked in discussions that address the risk of closing America's only strategic airlift production line include the following:

- What alternative strategic airlift platforms are in production?
- How many C-17s would DOD have to purchase to keep the C-17 line open?
- Can the C-17 line be shutdown in such a way that would allow it to reopen later?
- What are the long-term costs of keeping the C-17 production line open?
- What are the long-term force structure implications of continuing C-17 production?

Other Strategic Airlifters. Currently, the C-17 is the only strategic airlift aircraft specifically designed for military applications still in production. European

Aeronautic Defence and Space (EADS) Company is nearing production of the A400M that some tout as a potential strategic airlift competitor. Others counter that with less than one-half the payload capacity of a C-17 and roughly one quarter the payload capacity of a C-5, the A400M is too small to meet the Air Force's strategic airlift needs.[82] Reportedly, the Air Force has asked EADS for data on the freighter version of the A380 as a potential C-5 replacement.[83] While an A380 is capable of carrying a larger payload than a C-5, like most commercial aircraft, its airframe design has been optimized for carrying passengers and pallets. This may lead some to argue it is not suitable for moving outsized and oversized cargo like the C-5 or C-17.

C-17 Production Requirements. Boeing representatives say that depending on their success in negotiating near-term international sales of the C-17, Boeing will require funding for between 14 and 18 *Globemasters* in FY2008 or the production line will begin to shut down in January or February 2008 with a full shutdown in mid-2009.[84] However, to date, Boeing officials have kept the C-17 line open in anticipation of additional orders through the anticipated FY2008 supplemental war appropriations bill.[85]

Smart Shutdown Option. If Congress foregoes additional C-17 procurement, a decision will have to be made regarding maintaining capacity to build C-17s in the future. When planning for the C-17 line's end, the Air Force budgeted $650 million to be spent shutting down the line in a manner that would facilitate its restoration if necessary. The advantage of this strategy is that the government pays a one-time sum to hedge its bets. A disadvantage of a "smart shutdown" is that in addition to the monetary cost of storing and maintaining tooling necessary to build future C-17s, there is also risk associated with losing the expertise of the current C-17 production workforce. Some believe that Boeing may sell its production site at Long Beach, California, if the C-17 line closes. Having to restart C-17 production at a new location would likely further increase costs.[86] A comparison of estimated costs over different time spans between a "smart shutdown," followed by line restoration, and keeping the C-17 line open via additional purchases would be useful.

Long-term Cost Considerations. Some argue that purchasing aircraft predominantly to keep the line alive, while safeguarding rapid production capability,

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[82] According to EADS, the max payload of an A400M is 37 tons, or approximately 74,000 pounds. See [http://www.eads.com/1024/en/businet/miltrair/a400m/teca400m.html].

[83] Stephen Trimble, "Exclusive: US Considers Airbus A380 as Air Force One and potentially a C-5 replacement," Flightglobal.com, October 17, 2007.

[84] Telephone conversation between CRS and Boeing officials, February 26, 2007. "Boeing Announces C-17 Line May End in mid-2009; Stops Procurement of Long-lead Parts," *News Release*, Boeing Integrated Defense Systems, March 2, 2007.

[85] Damian Kemp, "Boeing Remains Confident C-17 Production Will Be Extended," *Jane's Defense Weekly*, February 6, 2008, at [http://www.janes.com].

[86] "C-17 Lobbying Picks up in Wake of Commerce Department Report," *Defense Industry Daily*, February 22, 2006, at [http://www.defenseindustrydaily.com/c17-lobbying- picks-up-in-wake-of-commerce-dept-report-01916].

also incurs billions of dollars of costs over the aircraft's lifetime. However, these life cycle costs could be offset to some degree if older aircraft were retired. When DOD officials defended the FY2006 budget decision to end C-17 procurement, they argued keeping the C-17 production line open "would be a smart thing to do" from a pure risk perspective, but "the cost would be prohibitive" given the other airlift procurement programs in Air Force plans.[87] In a 2005 study on mobility, the Defense Science Board (DSB) also considered risk an issue to consider in determining the total number of C-17s to purchase.

> The task force understands that each year of additional (C-17) production beyond 2008 would represent an additional $2.4 billion acquisition and $2-3 billion life cycle cost commitment, which the department must weigh against other war-fighting capabilities it could not acquire. However, in view of the prominence of organic strategic airlift in enabling rapid response to crises, the task force believes it is prudent to keep options open for the acquisition of additional C-17s.[88]

Long-Term Force Structure Implications. While decisions about C-5 modernization and C-17 acquisition must be made near-term, there are long-term implications to these decisions. For example, Air Force leaders have stated the C-5 RERP will enable C-5Ms to remain in service until 2040.[89] In 2040, C-17s will average 30-40 years old, potentially reaching the end of their service life. Will C-17s be viable candidates for a service life extension program after years of heavy use? Will pursuing DOD's current program of record result in DOD's entire strategic airlift fleet reaching the end of its service life at about the same time? When is the optimal time to shift focus to future technology that may be better tailored to support the very dynamic requirements expected to be driven by Army transformation?

Performance

Some argue that C-17 procurement should be increased at the C-5A's expense based on the potential likelihood of counter-insurgency operations in parts of the world with limited aviation infrastructure. A Cold War model of using strategic airlifters to transport large amounts of materiel from major stateside aerial ports to theater mobility hubs before trans-loading into smaller intra-theater aircraft for delivery into forward operating locations is no longer the most expedient airlift method. C-17s, able to operate in hostile and austere environments, remove long-standing seams traditionally woven together by strategic C-5s and tactical C-130s. Air mobility leaders often tout this concept of "velocity" as the ultimate measure of

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[87] Michael Sirak, "Senior DOD Officials Defend Decision To Halt C-17 Production At 180," *Defense Daily*, February 10, 2006.

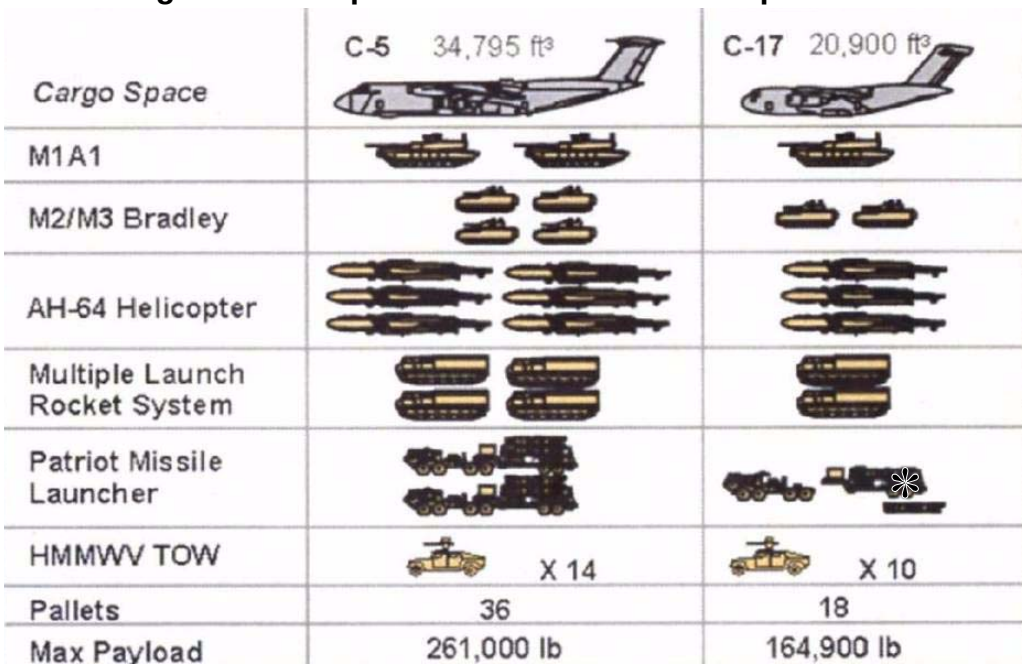
[88] *Defense Science Board Task Force on Mobility*, Office of the Under Secretary of Defense (AT&L), September 2005, p. 14.

[89] The Honorable Sue C. Payton, Assistant Secretary of the Air Force (Acquisition), Written Statement to the Senate Homeland Security and Governmental Affairs Committee, Federal Financial Management, Government Information, Federal Services, and International Security Subcommittee Hearing on Military Airlift Costs, September 27, 2007, p. 3.

success for airlift.[90] Some argue that velocity is improved by having a larger, mid-sized fleet capable of generating a larger number of sorties and supporting more point-to-point service.

The C-5's unique capabilities may also argue for its continuation, potentially at the expense of additional C-17s. In a period where DOD's force posture is moving from forward basing to expeditionary, it may be unwise to prematurely retire aircraft in today's inventory. In addition to its capability to carry approximately 60% more cargo than a single C-17, the C-5 can carry several unique loads that do not fit on a C-17. However, it is not clear how many C-5s are needed to meet DOD's requirement to carry loads that cannot fit on C-17s. Just as the C-17 can improve airlift velocity by providing planners with the ability to generate more sorties by supporting more point-to-point pairings, the C-5 is superior in moving bulk.[91] General Handy recalled, "in this last conflict [there were] many, many times when, frankly, the only way to unclog [Charleston AFB, SC, Dover AFB, DE, or Ramstein Airbase, Germany, was] to get the C-5 in there in sufficient numbers ... and literally, in a weekend, ... clean out all three aerial ports."[92] **Figure 2** provides a comparison of selected airlift loads that can be carried on C-17s and C-5s.

Figure 2. Comparison of C-5 and C-17 Capabilities



Source: *FY06 Congressional Overview (C-5, C-130J)*, "C-5 Operations During Iraqi Freedom," Lockheed Martin Aeronautics Company, p. 18.

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[90] Michael Sirak, "Payton: Air Force Expects First C-5 RERP Production Contract in Early 2008," *Defense Daily*, vol. 235, issue 1, October 1, 2007.

[91] Air transportation it typically conducted using two models: hub and spoke or point-to-point. Point-to-point service is faster because it takes cargo directly from origin (spoke) to destination (spoke) avoiding delays associated with connecting through major ports (hubs).

[92] John A. Tirpak, "Saving the Galaxy," *Air Force Magazine*, vol. 87, no. 1, January 2004, [http://www.afa.org/magazine/jan2004/0104galaxy.asp].

Fleet Mix

For many, potential cost and capability concerns intersect when reductions to the size of the C-5 fleet are discussed. DOD's program of record maintains a fleet of over 100 C-5Ms through the 2040s. If the C-5As are not modernized, sooner or later, the Air Force will be left with a fleet of approximately 50 C-5Ms. Some would argue that this would create another low density/high demand (LD/HD) challenge for the Air Force because of the relatively small number of C-5Ms that would remain in the inventory. Both the 1997 and 2001 Quadrennial Defense Reviews identified the challenges of operating and maintaining small aircraft fleets that are heavily used in peacetime and in war. Both studies recommended changes to asset management in order to reduce the prevalence of LD/HD aircraft fleets. Likewise, Air Force leaders have taken steps, such as implementing the Expeditionary Aerospace Force (EAF) construct, in part to mitigate the LD/HD problem. Conversely, others might argue that if the tonnage capacity of retired C-5s was replaced by C-17s, then a smaller C-5 fleet would not be in high demand as long as enough C-5Ms were retained to move bulk cargo shipments between air mobility hubs and large cargo loads unable to fit on smaller C-17s.

Some voice concern that a fleet composed entirely of one model of aircraft is less robust than a fleet composed of two aircraft types, pointing out that if one aircraft type is grounded for safety, the other can still fly. Others argue homogeneous fleets offer potentially significant savings in operations, training, and maintenance costs. Those that hold this view might point to Southwest Airlines — an airline that has turned an enviable string of profitable years in part by using a homogeneous fleet designed to minimize maintenance, training, and operating costs. Likewise, the bulk of DOD's intra-theater airlift fleet has been composed of just C-130s for decades.

Options for C-5 Modernization/C-17 Procurement

As the C-17 production line wanes, pressure is building to procure more aircraft. In effect, this brings long-term Air Force funding for C-17 production into direct competition with C-5 modernization. However, there are strong arguments for both programs, and viewing them from this "either/or" perspective may be unnecessary and counter-productive. Because the C-17 can perform both tactical and strategic airlift, it also competes to some degree with the C-130J for funding. Thus, decisions on C-130 recapitalization affect strategic airlift. Preferably, air mobility programs should be developed, planned, funded, and executed in a joint and interdependent way. Below are five commonly proposed tradeoffs between C-5 modernization and C-17 procurement, with some pros and cons for each course of action.

Modernize all C-5s and Purchase Additional C-17s

Advocates of this option might believe the current Mobility Capabilities Study (MCS) underestimated strategic airlift requirements or accepted too much risk. Some in Congress have encouraged DOD to procure more C-17s than are currently planned,

arguing airlift needs are increasing.[93] For example, General Schwartz recently stated that he believes the "sweet spot" for the strategic airlift fleet is 205 C-17s and 111 fully modernized C-5s.[94] These arguments are often based on planned force structure increases or Army plans to deploy faster that may foreshadow additional strategic airlift requirements. Finally, proponents might cite the economic and industrial benefits of continuing the C-17 production line. For example, a longer production run might allow potential foreign or civilian sales to come to fruition and provide a hedge against future uncertainty. One might also assert the C-17's capability to perform tactical airlift missions justifies continued production at the expense of C-130 buys. Others could argue adding dollars to the strategic airlift portfolio will pull scarce resources from higher priority programs in the zero-sum gain DOD budget when there is no quantified requirement present. Likewise, some DOD leaders caution against building too much strategic airlift capacity, as General Schwartz recently testified:

> In terms of organic capacity, too much aluminum is just as counterproductive as not enough. We should guard against overbuilding the organic fleet to the detriment of other strategic necessities, such as modernizing the aging tanker fleet or the viability of our commercial partners.[95]

Modernize All C-5s and Halt Acquisition of the C-17

This option was DOD's program of record until DOD cancelled the RERP for additional C-5As. Advocates of this approach note that DOD has not requested more C-17s during the budget process. Likewise, some assert that there are no validated requirements to justify purchasing additional C-17s for the tactical airlift role. Further, some state this option is backed by both the most recent MCS and the 2000 IDA study as the most cost effective solution.[96] Others counter that recent cost growth has invalidated C-5 RERP cost assumptions used in IDA's analysis. Opponents also criticize this approach because it allows the C-17 production line to shut down before operational testing validates whether C-5As can reach availability and reliability rates planned for in AMP and RERP. Further, some fear without the competitive option of C-17 buys, future C-5 RERP cost may soar.

Forego RERP on Some or All C-5s and Buy More C-17s

This option appears to most closely resemble DOD's current program of record. Another alternative is to accept the current mission-capable rates and availability of

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[93] Gail Kaufman, "USAF C-17s May Come Earlier Than Requested," *Defense News*, March 29, 2004.

[94] Amy Butler, "Schwartz Says No to C-17 Line Closure," *Aviation Week and Space Technology*, November 7, 2007, at [http://www.aviationweek.com].

[95] Hearing of the Senate Homeland Security and Governmental Affairs Committee, Federal Financial Management, Government Information, Federal Services, and International Security Subcommittee on Military Airlift Costs, September 27, 2007.

[96] *Analysis of Alternatives for Out- and Over-Size Strategic Airlift: Reliability and Cost Analyses*, Institute for Defense Analyses, IDA Paper P-3500, March 2000.

the C-5 fleet, but to invest some C-5A RERP dollars into additional C-17 procurement. Some favor this option because it preserves the unique outsize cargo capability of the C-5, keeps the C-17 production line open and allows DOD to move to a less risky point on the continuum established in the most recent MCS. However, it is unclear how many C-17s would be required to fill the airlift gap created by not improving C-5 reliability. Some may argue that the 10 C-17s Congress provided the Air Force with FY2007 funds is sufficient to compensate for the loss of one C-5 as a result of an accident, and DOD's decision to forego RERP on remaining C-5As. Skeptics also assert this option runs counter to analysis in the 2000 IDA study. **Table 5** summarizes the IDA study alternatives that compared the purchase of 180 C-17s with various mixes of C-5 fleets.

Table 5. Comparison of 180 C-17s with Various C-5 Fleets

Alternative	MTM/D	C-5A RERP upgrade	C-5B RERP upgrade	# of C-17s	LCC Constant $B	LCC Discounted $B	LCC Then-year $B
3	30.1	No	No	180	87.3	50.4	137.0
5	30.7	No	Yes	180	85.1	50.0	132.1
7	32.3	Yes	Yes	180	83.5	50.0	127.9

Source: Extracted from IDA Paper P-3500, March 2000. Tables 2 and 3 combined and adapted by CRS.

Note: All cost estimates expressed in $FY2000.

Although the IDA study is dated in many ways, a closer examination of the three alternatives that hold the number of C-17s constant at a total acquisition program similar to DOD's current program of record of 190 C-17s may prove helpful. Based on the assumptions IDA examined, fully modernizing all C-5s produced the highest airlift capacity in terms of million-ton-miles per day for the lowest life cycle costs. However, it is not clear where the near-term money would come from to keep C-17 production going, nor whether cost assumptions used in the IDA study invalidate this comparison.

Replace All C-5As with C-17s

DOD could also replace all C-5As with C-17s. A principal advantage of this approach is investing budget resources into new aircraft thereby facilitating recapitalization of the Air Force's aging fleet. Some believe that this might provide a more flexible airlift fleet than DOD's current program of record and would closely mirror Air Force plans prior to being faced with C-5 retirement restrictions from Congress.[97] However, some contend that this option runs counter to analysis conducted by both the Rand Corporation and IDA. Others point out that this option would likely take resources from potentially higher DOD acquisition priorities. Like the "30/30" proposal discussed below, murkiness of requirements as defined in the

[97] U.S. Representative Jim Saxton, "There's More To The Story," *Washington Post*, October 30, 2007, p. 14.

latest MCS makes it unclear how many C-17s would be required to replace retiring C-5s. Further, it is also unclear whether this approach would leave DOD with sufficient C-5s for cargo that can only be carried by the *Galaxy* or that would optimally be transported on a C-5.

Replace 30 C-5As with 30 C-17s

In early 2007, senior Air Force officials proposed buying 30 additional C-17s instead of modernizing 30 C-5As. Likewise, it was reported Boeing provided the Air Force with an unsolicited bid for a multiyear purchase of 30 *Globemasters* purchased at a rate of 10 per year. According to the report, the cost of purchasing 30 C-17s and retiring 30 C-5s was roughly equivalent — "couple hundred million dollars apart," but where the Air Force would find funds for this proposal is unclear.[98] Proponents of this idea argue it would allow the Air Force to retire the oldest or poorest performing A-models and invest in the youngest portion of the C-5 fleet — the portion that has the most time to return dividends on the up-front RERP investment. Opponents of this option contend this approach is premature because operational testing of the first A-model upgraded to the C-5M configuration is incomplete. Likewise, because of budget pressures, a "30/30" proposal may only be executable as an add to the FY2008 GWOT request.[99] Furthermore, skeptics may point out the Air Force has not proven that there is a subset of the C-5A fleet that chronically underperforms the remainder of the fleet.

Replacing 30 C-5 aircraft with 30 C-17s might also present airlift capability issues. Airlift capability can be measured in different ways, but it appears clear that on a one-for-one basis, the C-5 can carry more outsize cargo and more cargo pallets than the C-17. In many cases, C-5s can carry twice as much of a given piece of outsize cargo as the C-17.[100] The C-5's advantage in size is offset, to a degree, by lower availability. Thus, **Figure 2** does not compare accurately the two aircrafts' capabilities over multiple sorties. **Table 6** illustrates the effect the C-17's superior mission capable rate has on airlift capabilities by providing a simplified comparison of 30 C-5As, 30 C-5Ms, and 30 C-17s moving typical wartime loads over an intercontinental distance in a single day.

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[98] Carlos Munoz, "As Boeing Submits C-17 Bid to Service ... Air Force Floats Multiyear Globemaster Buy to Defense Lawmakers," Inside the Air Force, April 20, 2007, at [http://www.insidedefense.com/secure/defense_docnum.asp?f=defense_2002.ask&docnum=AIRFORCE-18-16-1].

[99] CRS interview with SAF/FML April 27, 2007.

[100] Outsize cargo is defined by DOD as cargo that exceeds the dimensions of oversized cargo and requires the use of a C-5 or C-17 aircraft or surface transportation: a single item that exceeds 1,000 inches long by 117 inches wide by 105 inches high in any one dimension.

Table 6. Typical Load Capabilities of 30 C-5A, C-5M, and C-17 Airlifters Considering Expected Mission Capable Rates (MCR)

	C-5A (50% MCR)	C-5M (75% MCR)	C-17 (85% MCR)
M1A1 Abrams	30	45	25
M2/M3 Bradley	60	90	51
AH-64 Apache	90	135	76
Patriot Missile Launcher	30	45	25
HMMWV TOW	210	315	255
Pallets	540	810	459
Maximum Payload	3,915,000 lbs.	5,872,500 lbs.	4,204,950 lbs.

Source: CRS. Figures extrapolated from data provided by Lockheed Martin.

Other Strategic Airlift Options

At least four other approaches have been suggested to address DOD's strategic needs. These approaches include increasing use of commercial aircraft, encouraging foreign or civilian sales of C-17s, bolstering reliance on pre-positioning of equipment, leveraging potential KC-X airlift capabilities, and pursuing airships. Like the tradeoffs of buying C-17s compared with upgrading C-5s, each of these options has strengths and weaknesses. These options are not mutually exclusive from the C-5/C-17 debate, as some might be pursued concurrently.

Increased Use of Commercial Aircraft

DOD currently contracts with civilian carriers to move passengers and cargo. Under the Civil Reserve Air Fleet (CRAF) program, DOD can also obtain use of additional civilian airliners to augment the Air Force's organic strategic airlift fleet.[101] Some suggest that DOD should increase the use of commercial aircraft, which offer many advantages over dedicated military aircraft. Commercial aircraft are numerous, tend to have longer range, and are typically less expensive to buy and operate than most military aircraft. However, civilian aircraft also have limitations. Most cannot carry outsized cargo, conduct special missions like airdrops, or support special operations. Also, they tend to congest airfields because of longer ground times resulting from a lack of roll on/roll off capability and reduced ramp maneuverability.[102] Further, potential hostile fire effectively deters civilian crews from entering combat zones. It is noteworthy that during Operations Enduring

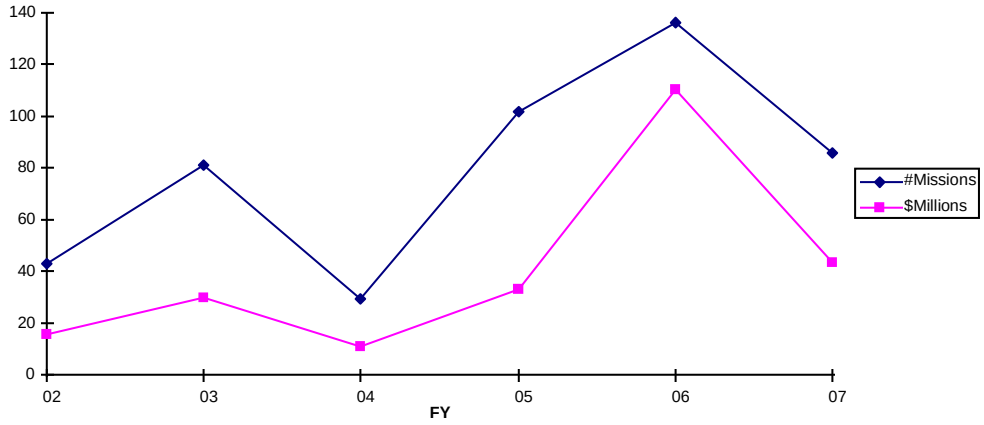
[101] See CRS Report RL33692, *Civil Reserve Air Fleet*, by Christopher Bolkcom.

[102] Robert C. Owen, Professor, Embry-Riddle Aeronautical University-Daytona Beach, FL, "Transport Trade-offs," written in response to a previous letter to the editor in "Correspondence," *Aviation Week and Space Technology*, October 8, 2007, p. 8.

Freedom and Iraqi Freedom, DOD has leased Russian An-124 aircraft to carry outsize and oversize cargo.

The An-124 Condor is a strategic lift aircraft larger than, but comparable to, the C-5. It also appears that DOD use of An-124 missions is accelerating. Some contend that while C-5s may not be as modern as C-17s, or able to operate from as many runways, the fact that DOD is outsourcing missions to Russian aircraft indicates C-5s offer important capabilities other U.S. aircraft may not be able to satisfy. In contrast, it is possible An-124 contract missions may be the result of the convenient availability of relatively low-cost airlift near a busy theater of operations. Since the Air Force retired 14 C-5s in 2004, the number of An-124 missions has increased. During congressional testimony, General Schwartz explained that costs associated with transporting Mine Resistant Ambush Protected (MRAP) vehicles to Iraq were about $130,000 per MRAP for both C-5s and An-124s — and less expensive than moving them on C-17s. However, he suggested An-124 reliability made it the logical choice stating, "because kids are in jeopardy, I'm not going to have airplanes broke in Europe or somewhere else when I have an alternative which, to date, has not resulted in a late delivery."[103] **Figure 3** illustrates that the Air Force has spent nearly $170 million since FY2002 for An-124 missions.

Figure 3. Number and Cost of An-124 Missions Contracted by Air Mobility Command



TOTAL: 434 missions. $168,434,265.00

Source: USAF Air Mobility Command, International Airlift Procurement Branch, February 23, 2007.

Perhaps DOD is already exploiting commercial aircraft to its maximum potential. The Air Force indicates in the MRS-05 study that it could not use the 20.5 MTM/D of CRAF capability assigned for most of the halt phase of the wartime scenarios studied, because of the limitations listed above. Likewise, planning to utilize foreign-owned contract carriers during contingency operations might be risky

[103] Hearing of the Senate Homeland Security and Governmental Affairs Committee, Federal Financial Management, Government Information, Federal Services, and International Security Subcommittee on Military Airlift Costs, September 27, 2007.

because of potential political constraints a foreign carrier's government may impose on their use.

Encourage Civilian/Foreign C-17 Sales

Civilian sales and international exports of C-17s are seen as potentially complementary methods of keeping the C-17 production line open and reducing the per-unit production costs. Likewise, foreign military sales could potentially reduce allied nations' demand on U.S. strategic airlift platforms in future operations.

BC-17X. One civil aircraft initiative that may have some utility for the military is the effort by Boeing, with the Air Force's endorsement, to market a civilian version of the C-17. Appropriations conferees have directed the Air Force to study options for commercializing the heavy, outsized aircraft for incorporation into the CRAF.[104] However, is there sufficient market for these aircraft to be commercially viable? In May of 2007, Boeing's C-17 Program Manager, Dave Bowman, stated, "we have several customers with money that have given us requests for proposals."[105] Some industry studies suggest that a commercial market for up to 10 C-17s may exist for use in heavy industry, mining, or similar endeavors, while Boeing believes there is market potential of "upwards of 100 aircraft."[106] The Air Force and Boeing have considered a number of different potential strategies to exploit or expand this potential market.

If the Commercial Application of Military Airlift Aircraft (CAMAA) were pursued, DOD would loan money directly to companies or guarantee their financing to enable purchase of C-17s from Boeing. Civilian owners of the BC-17X (as the commercial variant would be called) would make the aircraft available to DOD in time of need, much like CRAF. The Air Force proposed several options to "sweeten the deal," such as helping companies find customers who need outsized cargo delivery and providing them monthly military business paid for at commercial rates. In addition to having access to these aircraft, the Air Force and civilian users could benefit, because building BC-17Xs for civilian use would effectively exploit excess production capacity and help lower the per-unit cost of aircraft bought by DOD.[107] In October 2002, it was reported that DOD's Business Initiatives Council had approved CAMAA as an "efficiency measure."[108] However, DOD has reportedly cooled to this approach. In an April 2006 letter to Congress, Secretary Michael

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[104] H.Rept. 108-553, p. 77.

[105] Guy Norris, online at Flightglobal.com, May 23, 2007.

[106] Ibid.

[107] Amy Butler, "Commercial C-17 Buys Would Stabilize Cost, Enhance Reserve Air Fleet," *Inside the Air Force*, December 22, 2000; Christian Lowe, "Air Force Issues Draft Solicitation for Civilian C-17s," *Defense Week*, July 9, 2001.

[108] "DOD Business Initiatives Council Supports C-17 'Commercialization,'" *Defense Daily*, October 16, 2002, p. 8.

Wynne wrote the Pentagon's recent reviews of mobility requirements determined there is no need for an outsized, commercial aircraft in CRAF.[109]

A second strategy could be for the Air Force or the General Services Administration (GSA) to sell used C-17s to commercial companies. Commercial clients would, presumably, be interested in used aircraft because they would cost less than new aircraft. As part of the arrangement, commercial owners would make the aircraft available to DOD in times of crisis, thus increasing the potential inventory of outsize/oversize airlifters available to DOD. The Air Force could use the proceeds from the sales to help finance the purchase of new C-17s.

A third approach might allow the Air Force to trade older C-17s to Boeing and receive credit toward the purchase of new ones. Reportedly, the Air Force prefers this option over selling aircraft directly to commercial companies because it would avoid potential costs with certifying C-17s for civil application.[110] Some analysts might question why the Air Force would want to sell any of its C-17s if there is a growing requirement for them.

The feasibility of these strategies is unclear as few companies may wish to risk investing in expensive outsize cargo aircraft. Conversely, one private company — *Cargo Force* — has publicly stated a desire to purchase 25-80 C-17s, but alleges that DOD is blocking deals fearing commercial sales may dampen Congress's interest in funding more C-17s for the Air Force.[111] Some also question Congress's appetite for unconventional financing and procurement strategies in the aftermath of the KC-767 tanker lease proposal.[112] Creative attempts to establish an outsize/oversize commercial market using C-17s would likely have to be done without DOD incurring financial liability.[113]

Foreign Sales. Allied nations also have strategic airlift requirements that could potentially be satisfied by the C-17. In August 2006, the Royal Australian Air Force awarded Boeing a $780 million contract for four C-17 aircraft.[114] Likewise, Canada is also importing four C-17s.[115] Whether the C-17 is successful in the export market will be determined in part by its competition. The most prominent competitor is EADS's A400M aircraft. Having long recognized a deficit in long-range airlift

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[109] Jason Sherman, "Wynne: No Room for Commercialized C-17 in Civil Reserve Air Fleet," *Inside Defense.com*, April 6, 2006.

[110] Cynthia Di Pasquale, "Pentagon Proposes Trading in Older C-17s to Boeing to Grow CRAF," *Inside the Air Force*, April 22, 2005.

[111] Dave Ahearn, "Air Force maneuvers to Ensure it Gets 220 C-17s — Analyst," *Defense Today*, March 7, 2005.

[112] See CRS Report RL32056, *The Air Force KC-767 Tanker Lease Proposal: Key Issues for Congress*, coordinated by Christopher Bolkcom.

[113] Di Pasquale, op.cit.

[114] "Boeing to Provide Four C-17s to Australia Air Force," *Defense Daily*, August 1, 2006.

[115] "Canada to Spend $1.3 billion for Four Boeing C-17 Globemasters," *Defense Daily*, September 15, 2006.

capabilities, several NATO countries (Germany, France, Spain, Britain, Turkey, Belgium, and Portugal) plan on purchasing the jointly developed A400M turboprop airlifter. This program has experienced numerous perturbations in schedule and budget. In December 2002, for example, Germany announced that it would reduce its planned acquisition of the A400M from 73 to 60 aircraft. In October, 2007, EADS informed A400M customers to expect delivery delays of 6 to 12 months.[116]

British defense officials view the C-17 as an asset that can be used in rapid-reaction operations. The United Kingdom's Strategic Defense Review of July 1998 first indicated that the Ministry of Defense might lease or buy several C-17s to meet air mobility requirements of Britain's Rapid Reaction forces. In August 2006, it was reported that the U.K.'s Royal Air Force had committed to purchasing outright four C-17s it had leased from Boeing and would purchase a fifth aircraft in 2008.[117] In July 2007, the United Kingdom Ministry of Defense announced purchase of a sixth C-17 to fill strategic airlift needs.[118] Britain had "conditionally committed" to purchase 25 Airbus A400M transports following the C-17 lease, but it is unclear whether the U.K. will purchase additional C-17 instead of the A400M aircraft. Continued delays could drive customers to alternatives like the C-17 or C-130J. **Table 7** summarizes C-17 foreign military sales.

Table 7. C-17 Foreign Sales

County	C-17 Orders
Australia	4
Canada	4
United Kingdom	6

Source: *Defense Industry Daily*, "Defense Industry Daily Focus: The Global C-17 Sustainment Partnership," September 13, 2007, at [http://www.defenseindustrydaily.com].

Note: The contract for a sixth RAF C-17 has not been finalized.

In September 2006, NATO announced members had signed a letter of intent to jointly purchase up to four C-17 aircraft.[119] These aircraft are intended to be shared by member nations in what amounts to a time-share plan.[120] To support this effort, Section 1032 of the FY2008 Defense Authorizations Act allowed the Air Force to

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[116] Press Release, "EADS informs A400M Customers about Revised Delivery Schedule," Amsterdam, October 17, 2007.

[117] "More C-17s," *Aerospace Daily & Defense Report.* August 8, 2006.

[118] United Kingdom Ministry of Defense Press Release, July 27, 2007, online at [http://www.mod.uk/DefenceInternet/DefenceNews/EquipmentAndLogistics/BrownePurchaseOfExtraC17WillsignificantlyBoostUkMilitaryOperations.htm].

[119] Nicholas Fiorenza, "NATO pools resources to buy C-17s," *Jane's Defence Weekly*, September 13, 2006.

[120] Each C-17 will be programmed to fly 1,000 hours yearly. Participating nations will share costs based on the number of flying hours reserved for annual utilization.

send one C-17 from the current inventory in addition to NATO's proposed buy.[121] In return, the Air Force would receive an amount of time equal to one C-17 (approximately 1,000 flying hours annually) from the proposed program to meet current and future airlift requirements. Reportedly, Boeing hopes to secure a firm commitment from NATO in April 2008.[122] Some Persian Gulf states have reportedly expressed interest in the C-17 with an eye toward increased participation in humanitarian or disaster relief missions. As with the proposed NATO arrangement, C-17s could be purchased by individual states or as part of a consortium.[123] If these sales come to fruition they would represent a significant boost for the *Globemaster's* export prospects.

Bolster Reliance on Pre-positioning of Equipment[124]

Potential risk incurred by ending C-17 production is not apportioned solely over the airlift fleet. Long-range cargo aircraft are only one component of a larger military mobility system. While aircraft offer advantages over other transportation modes, such as speed and flexibility, these characteristics may potentially be offered by a mix of other assets. Both the Defense Science Board and the Congressional Budget Office (CBO) recommended that DOD improve its mobility capabilities by increased investments in afloat pre-positioning of equipment, not by large investments in fixed-wing long-range airlift. For example, the DSB found that

> investments now in intermediate staging bases, more and improved force and sustainment pre-positioning and high-speed, intratheater vessels capable of austere port access could add significant new capabilities to enable land force deployments and meet a variety of contingencies. These investments need to be complemented by incremental investments in aerial tankers and possibly in strategic airlift.[125]

Both the DSB and CBO found pre-positioning equipment offered opportunities to increase delivery velocity. For example, the DSB found that "pre-positioning is the sole component of the mobility system that can deliver employable heavy/medium land forces early in a campaign."[126] CBO added, "Prepositioning sets of unit equipment offers greater improvements in the promptness of cargo deliveries than the other options that CBO examined" such as increasing airlift and fast sea-lift

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[121] H.Rept. 110-477, Section 1032, December 6, 2007.

[122] Damian Kemp, "Boeing Remains Confident C-17 Production Will Be Extended," *Jane's Defense Weekly*, February 6, 2008, on-line at [http://www.janes.com].

[123] Michael Sirak, "Air Force Promotes Airlift Options for Middle East Partners," *Defense Daily*, vol. 236, issue 32, November 14, 2007.

[124] See CRS Report RL32513, *Navy-Marine Corps Amphibious and Maritime Prepositioning Ship Programs: Background and Oversight Issues for Congress*, by Ronald O'Rourke.

[125] *Defense Science Board Task Force on Mobility*. Office of the Under Secretary of Defense (AT&L), September 2005, p. 14.

[126] Ibid., p.10.

capabilities.[127] Further, "increasing the number of existing ships and aircraft would offer very limited improvements in the promptness of unit deliveries during large deployments."[128]

Further, there are some instances where an increased reliance on strategic airlift could exacerbate logistical choke-points potentially slowing the deployment of forces. Often, the transportation problem is not too few aircraft, but too few airfields or poor infrastructure. A study conducted by the Army's Military Traffic Management Command found the biggest roadblock to achieving the service's deployment goals is limited infrastructure at forward airfields.[129] Infrastructure shortfalls could include a lack of ramp space or loading/unloading equipment. During Operation Allied Force, for example, "there were not enough air bases in the area immediately around Kosovo to support all the aircraft...."[130] In addition, the CBO observed,

> Aircraft offer rapid delivery of individual loads, but any attempt to significantly increase their total cargo deliveries to a distant theater would probably be hampered by constrained infrastructure at airfields, which is anticipated for many, if not most, future conflicts.[131]

Leverage Next Generation Tanker's Airlift Capability[132]

Acquisition decisions regarding KC-X, the Air Force's next generation tanker program, may also affect strategic airlift capability. First, some believe DOD should factor airlift capacity of tankers into strategic airlift requirements derived from mobility capability studies. Both competitors for the KC-X program, the KC-30 based on the Airbus 330-200 and the KC-767 based on Boeing's 767-200, could add airlift capability compared to the KC-135s they are envisioned to replace. However, in congressional testimony General Schwartz stated that KC-X proposals are not expected to have the roll-on/roll-off capability of the Air Force's current strategic airlift fleet or the ability to handle oversized or outsized cargo.[133] Others also point out that airlift is a secondary mission for aerial refuelers and that tanker capability could be fully tapped to perform core refueling missions during times of peak airlift

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[127] *Options for Strategic Military Transportation Systems*, Congressional Budget Office, September 2005. p. x.

[128] Ibid, pp. x, xiii.

[129] Kim Burger, "Army Study: Poor Forward Airfields Jeopardize Deployment Goals," *Inside the Army*, August 21, 2000.

[130] *Kosovo After Action Review*, Secretary of Defense William S. Cohen and Gen. Henry H. Shelton, Chairman of the Joint Chiefs of Staff, Senate Armed Services Committee, October 14, 1999.

[131] *Options for Strategic Military Transportation Systems.* Op cit. p. x.

[132] See CRS Report RS20941, *Air Force Air Refueling*, by Christopher Bolkcom.

[133] Hearing of the Senate Homeland Security and Governmental Affairs Committee, Federal Financial Management, Government Information, Federal Services, and International Security Subcommittee on Military Airlift Costs, September 27, 2007.

demand. Therefore, some argue that tanker airlift capacity should be viewed as additive to other transportation means when calculating strategic airlift requirements.

Even though airlift is viewed as a secondary mission for KC-X, most agree airlift capacity on tankers can reduce strain on the strategic airlift fleet. General Schwartz expects the KC-X to "mitigate wear and tear on the C-5 and C-17."[134] The Air Force envisions KC-X to be built from the outset with reinforced floors necessary for carrying either passengers or cargo in the fuselage, a cargo door sized to facilitate loading and off-loading, and defensive systems enabling a KC-X to land in certain combat environments.[135] With these capabilities, a KC-X could potentially fly a scheduled combat air refueling mission, be subsequently retasked in-flight, land at an airfield located within a threat environment, upload battle casualties, and air evacuate the patients to needed medical care in another theater. This illustrates how a KC-X, with defensive systems not currently found on KC-135s, might give planners additional options to execute an unplanned medical evacuation sortie perhaps negating the need to tap a strategic airlift platform. Likewise, this scenario could be applied to the movement other time-sensitive cargo or passengers. Thus, some believe purchasing a KC-X platform with robust airlift capabilities may extend the service life of other airlifters. Reportedly, the KC-X competition winner is expected to be announced by as early as February 2008.[136] **Table 8** summarizes airlift capability of selected air refueling platforms.

Table 8. KC-135 and Potential KC-X Airlift Capabilities

	KC-135	KC-30	KC-767
Passengers	54	280+	200
463L Pallets	6	32	19
Defensive Systems	No	Planned	Planned

Source: USAF, Northrop Grumman and Boeing. KC-135 information derived from KC-135 Stratotanker Fact Sheet, [http://www.af.mil/factsheets/factsheet.asp?id=110], and the Air Force Handbook 2007.

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[134] General Norton A. Schwartz (USAF), Commander, U.S. Transportation Command, Written Statement before the Senate Homeland Security and Governmental Affairs Committee, Federal Financial Management, Government Information, Federal Services, and International Security Subcommittee, September 27, 2007, p. 6.

[135] Defensive systems facilitate a tanker aircraft's primary mission of in-flight air refueling by potentially enabling the tanker to operate closer to its refueling track, thus making more fuel available on each mission. As this example illustrates, defensive systems also increase a tanker's capability in its secondary mission of airlift.

[136] Richard Cowan, "U.S. Air Tanker Deal Pick by End of February — Official," *Reuters*, February 14, 2008.

Pursue Airships or Hybrid Airships[137]

Another potential strategy to bolster strategic airlift capability might be to re-invigorate DOD efforts to develop heavy-lift airships. Before Congress cancelled the program in 2006, the Defense Advanced Research Projects Agency was developing a hybrid airship capable of transporting up to 1,000 tons across international distances. Unlike traditional, cigar-shaped airships, a hybrid airship is shaped more like an aircraft's wing, to generate lift through aerodynamic forces. Advocates hope airships may be capable of carrying a complete Army brigade directly from "the fort to the fight," overcoming logistic choke points and mitigating the effects of limited forward basing.

In addition to very large payloads and long range, airships and hybrids may offer other advantages to the strategic airlift mission. First, they may not require as expensive and as specialized infrastructure as aircraft. A CBO study estimated developing and procuring 14-16 heavy-lift airships would have the same life cycle cost as 21 C-17 aircraft ($11 billion) but would deliver cargo at a rate nearly three times greater. Second, they may be able to deliver their payloads near the conflict, rather than at ports or airfields miles to the rear, thus overcoming logistic choke points and mitigating the effects of limited forward basing. Airships and hybrids may be able to land on water, which could prove valuable in realizing the Department of the Navy's sea basing concept.

Detractors challenge airship survivability and ability to operate in adverse weather. Also, *hybrid* airships use aerodynamic lift and will take-off and land much like conventional aircraft. Some estimate that 1,000 ton-class hybrid aircraft will require 5,000 foot-long runways.[138] Along with loading/offloading equipment and facilities, these runways appear to constitute infrastructures like those required by conventional aircraft. In addition, delivering a brigade-sized payload directly to a theater of conflict sounds attractive from a conventional wisdom point of view. However, large payloads take longer to consolidate, load, and unload than smaller payloads, and the their delivery must be tightly scheduled. Likewise, the in-flight loss of a single airship carrying a 3,500-soldier brigade could be both operationally and politically catastrophic. Finally, while life-cycle costs for these concepts could be notably less than manned aircraft, can DOD find budget room for another procurement program?

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[137] See CRS Report RS21886, *Potential Use of Airships and Aerostats*, by Christopher Bolkcom.

[138] John Wood, "Airships: Good for Business, or Good for Nothing?" Presentation before the 5th International Airship Convention & Exhibition, August 2004, Oxford, England.

Appendix A. C-5 System Description[139]

Power plant:	Four General Electric TF-39 engines
Wingspan:	222.9 feet (67.89 meters)
Length:	247.1 feet (75.3 meters)
Height:	65.1 feet (19.84 meters)
Cargo compartment:	length, 143 feet, 9 inches (43.8 meters); width, 19 feet (5.79 meters); height, 13.5 feet (4.11 meters)
Speed:	518 mph (.77 Mach)
Service ceiling:	45,000 feet (13,716 meters)
Range:	Global with in-flight refueling
Crew:	Seven (2 pilots, 2 flight engineers, and 3 loadmasters)
Maximum T/O weight:	769,000 pounds (348,818 kilograms) in peacetime; 840,000 pounds (381,024 kilograms) in wartime
Load:	81 troops and 270,000 pounds (122,472 kilograms) of cargo (36 pallet positions) simultaneously

Basing. Active duty C-5s are stationed at Dover AFB, DE, and Travis AFB, CA, in associate units teamed with the Air Force Reserve.[140] C-5s are assigned to Reserve units at Lackland AFB, TX; Westover Air Reserve Base, MA; and Wright-Patterson AFB, OH, and to Air National Guard (ANG) units at Martinsburg ANGB, WV; Memphis, TN; and Stewart ANGB, NY.[141]

Figure 4. C-5 Galaxy at Balad Air Base, Iraq

Source: USAF photo by SSgt Toney R. Tolley.

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[139] Derived from C-5 Galaxy Fact Sheet, [http://www.af.mil/factsheets/factsheet.asp?fsID=84], and *Air Force Magazine*, 2007 USAF Almanac, May 2007, p. 146.

[140] Associate units share aircraft between the active duty Air Force and either the Air Force Reserve or the Air National Guard components.

[141] Derived from C-5 *Galaxy* fact Sheet, [http://www.af.mil/factsheets/factsheet.asp?fsID=84], and *Air Force Magazine*, 2007 USAF Almanac, May 2007, pp. 105-108.

Appendix B. C-17 System Description[142]

Power plant:	Four Pratt & Whitney F117-PW-100 turbofan engines
Wingspan:	169 feet 10 inches (to winglet tips) (51.76 meters)
Length:	174 feet (53 meters)
Height:	55 feet 1 inch (16.79 meters)
Cargo compartment:	length, 88 feet (26.82 meters); width, 18 feet (5.48 meters); height, 12 feet 4 inches (3.76 meters)
Speed:	450 knots at 28,000 feet (8,534 meters) (Mach .76)
Service ceiling:	45,000 feet at cruising speed (13,716 meters)
Range:	Unlimited with in-flight refueling[143]
Crew:	Three (two pilots and one load master)
Max. T/O weight:	585,000 pounds (265,352 kilograms)
Load:	102 troops/paratroops; 36 litter and 54 ambulatory patients and attendants; 170,900 pounds (77,519 kilograms) of cargo (18 pallet positions)

Basing. Active duty C-17s are based at Charleston AFB, SC; Dover AFB, DE; Edwards AFB, CA; Elmendorf AFB, AK; Hickam AFB, HI; McChord AFB, WA; McGuire AFB, NJ; and Travis AFB, CA, in associate units. The Air Force Reserve operates eight C-17s at March ARB, CA; the ANG operates eight at Jackson, MS.[144]

Figure 5. C-17 Globemaster III Taking Off from Unfinished Runway

Source: USAF photo by 1st Lt. Laurel Scherer.

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[142] Derived from C-17 Globemaster III Fact Sheet, [http://www.af.mil/factsheets/factsheet.asp?fsID=86], and *Air Force Magazine*, 2007 USAF Almanac, May 2007, p. 146.

[143] The first 70 C-17s have an unrefueled range of 4,370 miles with a 90,000 lb. load. An extra fuel tank was installed on the 71st and subsequent aircraft extending unrefueled range to 5,060 miles with a 90,000 lb. load. Seena Simon, "Extra Fuel Tank Allows C-17s to Fly Farther," *Air Force Times*, April 2, 2001.

[144] Derived from C-17 Globemaster III Fact Sheet, [http://www.af.mil/factsheets/factsheet.asp?fsID=86], and *Air Force Magazine*, 2007 USAF Almanac, May 2007, pp. 105-108.

Appendix C. C-5 and C-17 Availability, and Readiness Comparisons[145]

Comparison of C-5 Fleet for 3 Availability / Reliability Measures FY05-FY07

Worst C-5s for Depot %

Tail #	Depot%	MCR	MXR
69000003	58.5	27	83.1
70000445	54.2	46.5	84.4
68000219	47.5	37.2	75
70000456	47.3	29.7	83.3
69000025	46.2	27.4	78.9
87000038	39.1	58.6	75.5
68000220	36.5	42.9	84.3
68000224	35.7	45.9	82.2
70000447	34.3	49.9	83.5
70000453	31.1	47	80
70000446	30.9	51.9	81.5
68000212	30.3	35.7	82.7

C-5A Fleet Avg. 21.3

Worst C-5s for Mission Capable Rate

	Depot%	MCR	MXR
69000014	5.6	26.4	87.3
69000003	58.6	27	81.1
69000025	46.2	27.4	78.9
70000456	47.4	29.7	85.6
70000451	7.1	33.1	78.9
68000215	6.1	33.8	82.2
70000457	24.9	34.5	73.2
68000212	30.3	35.7	82.7
68000219	47.6	37.2	75
70000460	41.5	38.9	83.6
70000455	6.8	39.3	85.6
68000221	2.3	39.7	81.5

C-5A Fleet Avg. 48.2

Worst C-5s for Mission Departure Reliability

	Depot%	MCR	MXR
70000168	0	59.1	50
70000461	12.6	44.6	70.1
70000462	24.7	65.3	71.4
69000010	1	65.9	71.4
84000059	63	62.3	73.1
70000457	24.9	34.5	73.2
69000020	22.1	42.6	74.6
68000219	47.6	37.2	75
85000005	51.3	58.2	75.6
87000029	15.1	62.8	75.6
87000045	42.3	59.6	75.8
67000174	0	48.8	76.9

C-5A Fleet Avg. 83.1

Tail Numbers in:

Italics = worse than average in all 3 categories

Bold = among the worst (not just below average) in two of the three categories

Bold and Background = among the worst in all three categories

[145] Source of charts: CRS, based on data provided by AMC.