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Intratheater Airlift Functional Solution Analysis (FSA)

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Prepared for the United States Air Force
Approved for public release; distribution unlimited

RAND PROJECT AIR FORCE

The research described in this report was sponsored by the United States Air Force under Contract FA7014-06-C-0001. Further information may be obtained from the Strategic Planning Division, Directorate of Plans, Hq USAF.

Library of Congress Cataloging-in-Publication Data is available for this publication.

ISBN: 978-0-8330-5085-4

Published 2011 by the RAND Corporation
1776 Main Street, P.O. Box 2138, Santa Monica, CA 90407-2138
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Summary

This monograph reports the findings of the FSA that RAND Project AIR FORCE produced for USAF intratheater airlift. The FSA is the third in a series of analyses that together constitute a CBA required as part of the JCIDS. The first, the FAA, identified the operational tasks, conditions, and standards needed to achieve military objectives—in this case, certain intratheater airlift missions.[1] The second, the FNA, assessed the ability of the current assets to deliver the capabilities identified in the FAA. The third document in the series, this FSA, assesses changes to current operations to determine whether a nonmateriel solution could close the capability gap identified in the FNA. If the FSA is unable to identify a nonmateriel solution to address the shortfall, an AoA is then undertaken to evaluate the cost-effectiveness of various materiel solutions. In this case, the analysis conducted after the FSA was called the USAF Intratheater Airlift Fleet Mix Analysis (UIAFMA).[2]

This assessment focuses on the movement of intratheater cargo and personnel. This mission is primarily driven by the joint land force requirement to move personnel, equipment, and supplies throughout the battlespace.

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1 Orletsky, Rosello, and Stillion, 2011.

2 Michael Kennedy, David T. Orletsky, Anthony D. Rosello, Sean Bednarz, Katherine Comanor, Paul Dreyer, Chris Fitzmartin, Ken Munson, William Stanley, and Fred Timson, *USAF Intratheater Airlift Fleet Mix Analysis*, Santa Monica, Calif.: RAND Corporation, 2010, Not Available to the General Public.

The FAA identified three broad operational mission areas for intratheater airlift: (1) routine sustainment, (2) time-sensitive, mission-critical (TS/MC) resupply, and (3) maneuver capabilities to U.S. and allied forces across all operating environments. The FAA drew the tasks, conditions, and standards required for intratheater airlift from a review of national strategy and official Department of Defense publications.

Two potential capability gaps were identified and analyzed in the FNA. The first is to maintain a sufficient number of C-130s to meet the requirement identified in the MCS.[3] The MCS set the minimum number of USAF mobility air forces (MAF) C-130s at 395 total aircraft inventory (TAI). A significant and growing portion of the C-130 fleet is either operating under flight restrictions or grounded because of fatigue-related cracking of key structural components of the center wing box (CWB). The second is to provide responsive intratheater resupply in support of the U.S. Army. The FNA looked at providing both routine sustainment and TS/MC resupply of a sizable multibrigade combat team (BCT) ground force. Although large multi-BCT forces operating without a ground line of communication is not the current Army concept for future operations, the trend is toward more-dispersed operations of ground forces. Future ground forces will rely on increased aerial distribution.[4]

The FNA found that if the policies of imposing flight restrictions and grounding aircraft remain in place and nothing else is done, then the number of unrestricted C-130s available to the USAF is projected to fall below the minimum threshold of 395 in the next several years. Further, the FNA found that routine sustainment of a ground combat force of moderate size by the existing intratheater airlift system is extremely challenging. In most of the cases analyzed, the number of C-130s required to supply six BCTs by air was at or beyond the number of C-130s likely to be available to support any one operation.[5] For

[3] DoD and JCS, 2005.

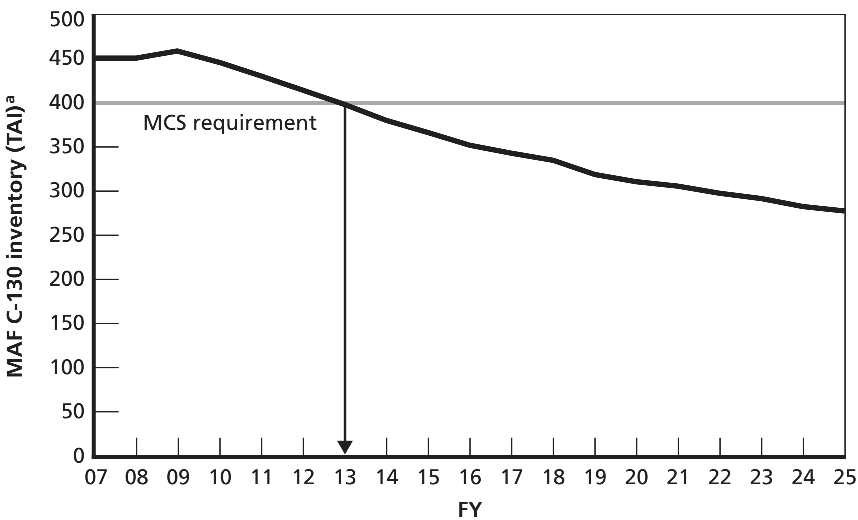
[4] See U.S. Army Aviation Center, Futures Development Division, Directorate of Combat Developments, *Army Fixed Wing Aviation Functional Needs Analysis Report*, Fort Rucker, Ala., June 23, 2003b, p. 16-17.

[5] We assumed one aircraft delivery to each of 18 battalion locations every eight hours.

TS/MC resupply, the FNA found that the existing intratheater airlift assets can be combined to provide a robust, responsive system with a reasonably small commitment of resources. In addition, the analysis suggests that allocating additional resources to the TS/MC mission results in rapidly diminishing returns in terms of reduced transit time.

Since routine resupply is not a requirement and since TS/MC resupply takes relatively few assets, the FNA determined that the FSA should focus on ensuring that the intratheater airlift fleet continues to meet the 395 C-130 requirement identified in the MCS.[6] This requirement needs to be met in light of the large number of aircraft that are expected to undergo flight restrictions and groundings during the next two decades. Using each aircraft's unique annual flying rate and equivalent baseline hours (EBH) accumulation rate, Figure S.1 projects the decline in the MAF inventory of C-130s over time as they reach the

Figure S.1
Number of C-130s in MAF Inventory and MCS Requirement



[a] Inventory numbers assume that all aircraft undergo TCTO 1908 inspection and are able to fly 45,000 EBH.

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6 DoD and JCS, 2005.

grounding limit.[7] The number of C-130s is projected to fall below the MCS requirement of 395 in 2013.[8]

Dealing with this emerging shortfall is complicated by the fact that aircraft are not distributed equally by age across active and reserve components. Figure S.2 shows that, in terms of years of service life remaining, the oldest aircraft are primarily in the active component, while the majority of the newer aircraft are in the reserve component. Thus, heavily tasked active forces face the most immediate prospect of not having enough aircraft to perform their missions.

FSA Methodology

The FSA identified 27 potential policy options to mitigate the capability gap the FNA identified. These potential solutions considered changes in doctrine, organization, training, leadership, personnel, and facilities. A screening process winnowed the potential solution options to a smaller set by making a first-order assessment of the potential effects of each option on the recapitalization date and the option's viability given other policy concerns. The solution options that offer potential with minimal associated negative effects or barriers to implementation were then analyzed in greater detail. A more-detailed analysis assessed the remaining options in terms of their potential effect on C-130 fleet life and their potential for closing the capability gap. The most promising options then underwent a net present value (NPV) cost analysis. Integrating the cost and effectiveness analyses provided a means to judge the viability of the potential policy options. SLEPs have high costs that

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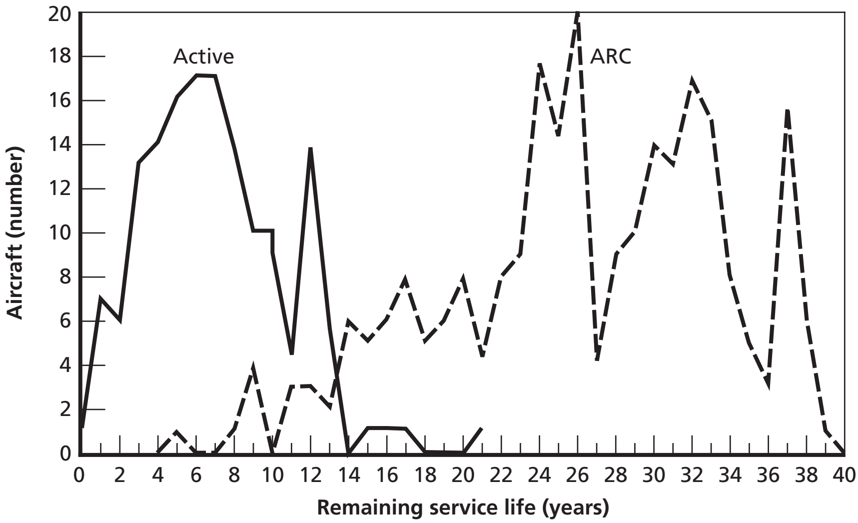
7 On January 3, 2007, there were 405 MAF C-130E/Hs and 37 C-130Js, for a MAF fleet of 442 aircraft on a TAI basis. Recent budget documents project that the Air Force will acquire an additional 28 MAF C-130Js by the end of FY 2010. The projection is based on Air Force Financial Management and Comptroller, *Committee Staff Procurement Backup Book: FY 2008/2009 Budget Estimates, Aircraft Procurement, Air Force*, Vol. I, Washington, D.C., U.S. Air Force, February 2007.

8 A new requirement of 335 C-130s is defined in *Mobility Capabilities & Requirements Study 2016*, which was released after the completion of this work. Figure S.1 indicates that the fleet will fall below the 335 requirement in 2017. (DoD, *Mobility Capabilities & Requirements Study 2016*, Washington, D.C., February 26, 2010, Not Available to the General Public.)

Figure S.2
Projected Service Life Remaining for Active and Reserve C-130s



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are on the order of new aircraft acquisitions and were therefore considered material options and analyzed in the UIAFMA. To provide a common metric between aircraft with different lifetime flying profiles, the EBH methodology was developed by the community. EBH provides a common measure of CWB damage for all aircraft. The EBH of each aircraft is tracked individually.

Leverage for Postponing the Need to Recapitalize

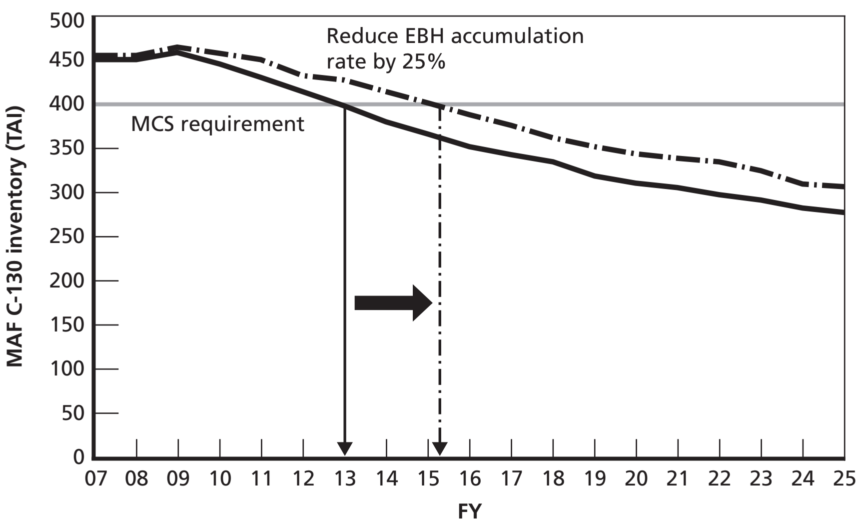
All potential solution options identified and analyzed during the FSA fell into one of three broad categories:

- reducing the EBH usage rate of the current C-130 fleet
- increasing the supply of EBH
- meeting the requirement with fewer C-130s.

To get an indication of the leverage each of these three categories of options offered, we made an arbitrary parametric change of 25 percent in each and measured the effects on the required C-130 recapitalization date. Although such changes would not necessarily be possible, the parametric analysis provided useful insights. These charts are intended to provide the reader with a sense of potential delay in the need to recapitalize that could be realized by making fairly significant changes in the three categories. This background should be useful to the reader later in the monograph during the discussion of the specific options we evaluated.

Figure S.3 shows that a 25-percent reduction in the EBH accumulation rate could delay the need to recapitalize by only about two years, to 2015, because so many C-130s are already close to retirement. Figure S.4 shows that an arbitrary 25-percent increase in the amount of EBH available for each aircraft prior to grounding could delay the need to recapitalize by about nine years, to 2022. However, flying

Figure S.3
Reducing Accumulation of Equivalent Baseline Hours by 25 Percent



NOTE: Ways to reduce usage rates include the use of simulators, companion trainers, and C-17 substitution.
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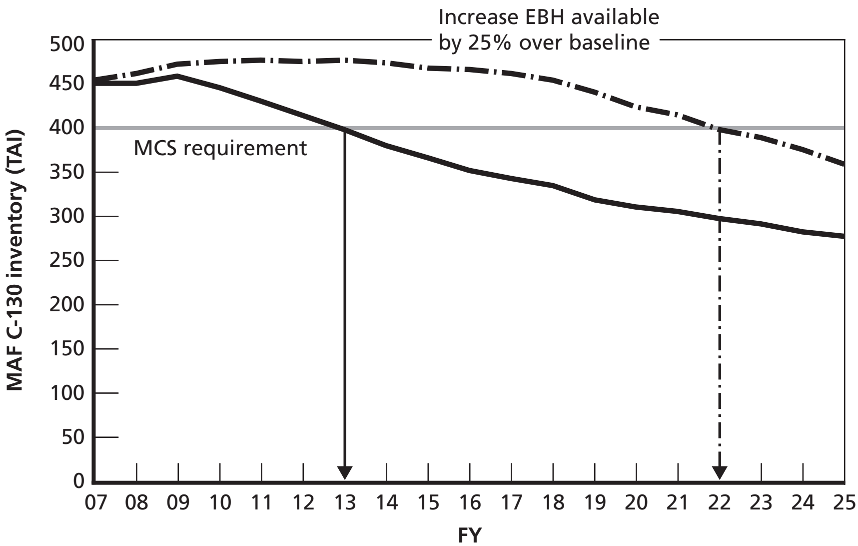
Figure S.4
Increasing Availability of Equivalent Baseline Hours by 25 Percent



NOTE: Increasing the supply of EBH increases EBH tolerance.
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beyond 45,000 EBH could entail significant risks of flight failure in the absence of actions to mitigate structural fatigue damage.[9] Figure S.5 shows that, if the MCS requirement could be met with 25 percent fewer C-130s, the recapitalization need could be delayed by about eight years, to 2021.

Comparison of Potential Solution Options

Tables S.1, S.2, and S.3 show the options considered in each broad category and their initial screening results. For each option, the potential impact of that option was assessed relative to the other options in the category (e.g., reducing EBH accumulation). Other implications—

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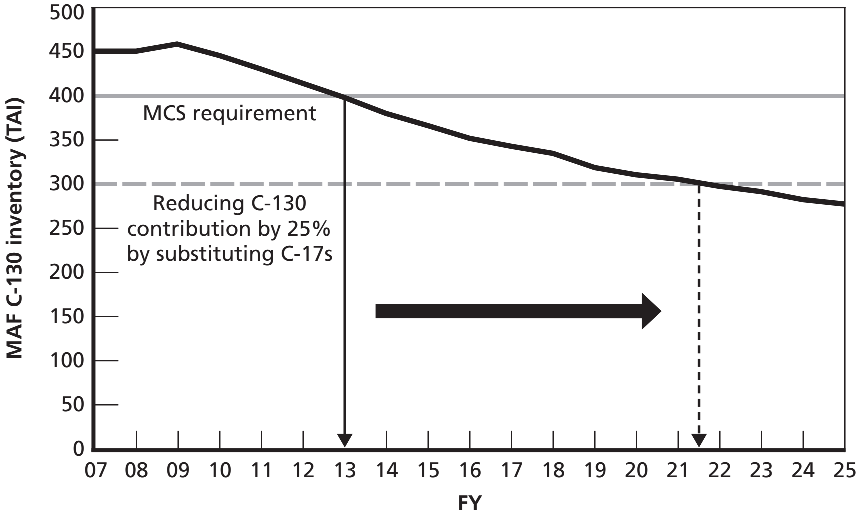
[9] The cases shown here give a sense of the leverage broad categories of policy solutions offer for addressing the capability gap. Increasing the EBH limit on each aircraft by 25 percent to over 56,000 EBH entails a great deal of risk. We consider this risk to be unacceptably high, unless significant modifications are undertaken to mitigate CWB structural fatigue issues.

Figure S.5
Meeting Mobility Capabilities Study Requirement with 25-Percent Fewer C-130s



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primarily negative implications—are presented. The potential leverage and impact on the fleet of each of these options must also be considered. Options that had good potential within a category and limited negative implications were then assessed in a cost-effectiveness analysis to determine the potential to delay the need to recapitalize the C-130 fleet.

Table S.1 shows potential options for reducing the rate of EBH accumulation. Although several options could significantly reduce the rate of EBH accumulation, none could significantly delay the need to recapitalize a C-130 fleet having so many high-EBH aircraft. The parametric analysis presented above shows that even a fairly significant reduction in the rate of EBH accumulation would delay the need to recapitalize by only one or two years, since many of these aircraft have only a few years of life remaining at the current operational tempo.[10]

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[10] For example, a 20-percent reduction in EBH accumulation on an aircraft that has four years of useful life remaining would extend the life of the aircraft by only one year.

Table S.1
Options for Reducing Equivalent Baseline Hour Accumulation

Options	Estimated Potential Effect	Other Implications
Most-promising		
Increase use of simulators for training	High	None
Increase use of companion trainer aircraft (CTA)	High	None
Shift high-severity-factor operational missions to other aircraft	High	None
Reduce crew qualifications	Moderate	Loss of capacity or flexibility
Reduce high-severity-factor training	Moderate	Loss of capacity or flexibility
Dropped in the screening process		
Rotate aircraft among components	Moderate	May not be viable
Increase experience mix	High	Effects on personnel
Change active-reserve mix	Moderate	Few active units Effect on temporary duty
Add ANG and/or AFRC associate units to active squadrons	Low	Crew ratio cuts needed
Increase squadron size	Very low	Reduced flexibility
Place flight restrictions on specific aircraft	Very low	Reduced flexibility

Key:
Green, *few* or *none*
Yellow, *moderate*
Red, *significant*

Most options that could provide a year or two of delay cost more in NPV terms than procuring new aircraft. All of these are nonviable because of the NPV cost.

The only potential option in this class that resulted in an NPV savings was increased use of simulators. Although potentially delaying recapitalization by only a year or two, this option has a significant NPV savings of about $7 billion—that is, about $200 million per year.

The second broad class of solution options increases the amount of EBH available. Table S.2 presents the potential options evaluated in this category. The parametric analysis showed that this class of option has good potential leverage. There are essentially two ways to do this. The first is a materiel solution (either SLEPing or buying new aircraft), and the second is flying the aircraft beyond 45,000 EBH on the CWB without conducting a SLEP. The SLEP option, a materiel solution, can involve repair, refurbishment, and replacement of structural components having fatigue or corrosion damage. This effectively resets the fatigue damage clock at a lower EBH. An initial assessment indicates that this option may be a cost-effective solution and should be evaluated in a future analysis along with the option of procuring new aircraft. SLEPs and new aircraft acquisitions are materiel solutions. Therefore, detailed analysis of these materiel solutions is left to the AoA.

Flying aircraft beyond 45,000 EBH without a SLEP was assessed as nonviable because of safety concerns. The risk of catastrophic structural failure increases greatly when an aircraft has more than 45,000 EBH on the CWB. Uncertainty about the accumulation of EBH for old aircraft complicates risk assessments. Over 30 to 40 years of usage,

Table S.2
Options for Increasing the Supply of Equivalent Baseline Hours

Options	Estimated Potential Effect	Other Implications
Most promising		
SLEP or repair the aircraft	High	Risks associated with aging aircraft
Buy additional aircraft	High	Additional capability Greater flexibility Reduced risk
Accept greater risk	High	Greater risk of catastrophic failure
Dropped in the screening process		
Develop better diagnostic tools	Moderate	Reduced uncertainty

Key:
Green, *few* or *none*
Yellow, *moderate*
Red, *significant*

fatigue life–monitoring approaches and methods for characterizing mission usage have changed several times. Gaps in the reporting of flight data also introduce uncertainties about the degree of fatigue damage. Moreover, the science of fatigue cracking is not completely understood. Inspections cannot completely compensate, since fatigue cracks are difficult to find and often missed during inspections.[11] At advanced levels of EBH, inspections cannot assure safety for aircraft with widespread fatigue damage. As a result, the amount of life gained from flying beyond the CWB grounding threshold does not appear to justify the significant risk of aircraft losses.

The third set of options evaluated—meeting the requirement with fewer C-130 aircraft—is shown in Table S.3. The parametric analysis showed that reducing the number of C-130s needed to meet the MCS requirement offered good leverage for delaying the fleet recapitalization date. Many of the options shown were dropped in the preliminary screening process because they either had little effect on delaying the recapitalization date or had other negative implications.

Using C-17s in the intratheater role and backfilling the strategic mission with additional Civil Reserve Air Fleet (CRAF) aircraft could potentially reduce the number of C-130s needed to meet the airlift needs identified in the MCS. However, we found this option problematic for several reasons. First, airlift requirements for the "Long War" and potential changes in the way the Army proposes to operate could drive intratheater airlift requirements well beyond those identified in the MCS. Ongoing operations in Iraq and Afghanistan have tied up a large number of C-130s over the last six years. If this level of commitment continues, the Air Force's ability to postpone the need to recapitalize is severely constrained by its need to maintain forces to support the demands of ongoing operations. Further, our analysis of the number of C-130s required to meet the MCS requirement depended on several MCS assumptions that were highly favorable to a C-130/C-17/CRAF

[11] For inspection of some fatigue-critical locations on C-130s, Warner Robins Air Logistics Center has assessed the probability of an inspection occurring properly, as specified, as being 0.5. As a result, the Air Force requires some critical inspections to be performed twice, with independent inspectors and engineering oversight, to raise the probability of a proper inspection to 0.75. Even with this heightened probability of success, cracks can be missed.

Table S.3
Options for Meeting the Requirement with Fewer C-130s

Options	Estimated Potential Effect	Other Implications
Most promising		
Shift some of strategic lift burden to CRAF and some C-17s to theater lift	High	None[a]
Shift more Air Education and Training Command (AETC) aircraft during peak demand	Low	None
Dropped in the screening process		
Shift some of theater lift burden to surface lift	High	Solution options may not be robust
Fly strategic airlift to FOLs	Moderate	Solution options may not be robust
Change theater routes	Low	Solution options may not be robust
Increase maximum number of aircraft on the ground (more civil engineering)	Low	Solution options may not be robust
Increase crew ratio	Low	Solution options may not be robust
Use Joint Precision Air Drop System	Low	Longer load times More training and qualification
Increase Army days of supply	Low	May increase need for tails
Pool joint airlift	Low	
Reduce number of aircraft subjected to a change in operational control (CHOPed)	None	None
Improve in-transit visibility	None	None

Key:
Green, *few* or *none*
Yellow, *moderate*
Red, *significant*

[a] The rating for this option reflects our initial screening. Further analysis indicated that this option is unworkable, principally because meeting the MCS requirement with fewer C-130s could leave the Air Force with inadequate force structure for sustained operations (i.e., the Long War requirement).

swap. As a result of the potential increased need for intratheater airlift beyond the scope of the MCS and the potential fragility of the option because of the favorable MCS assumptions, we judged the C-17 and CRAF substitution option not to be viable.

Conclusion

Table S.4 summarizes the assessment of options that underwent a detailed cost-effectiveness analysis. We found no viable nonmateriel solution or combination of nonmateriel solutions that could delay the need to recapitalize the fleet by more than a few years. Since no viable nonmateriel solution was identified in the FSA, an AoA should be

Table S.4
Summary of Results

FSA Option	Delays Need for Recapitalization by (years)	NPV	Other Implications
Meet MCS requirement with fewer C-130s			
Shift some C-17s to theater role; backfill with CRAF in strategic airlift			Long War dominates: Not viable
Shift more AETC aircraft during peak demand	~1–2		
Reduce EBH usage rate			
Shift more training to simulators	1–2	A savings of $7 billion	
Use CTA	1	A cost of $6 billion	
Shift some contingency missions to other mission design series	<1	A cost of $2 billion	
Increase EBH supply			
Fly aircraft beyond 45,000 EBH (fly to 56,000 EBH)	~9	Uncertain	Unacceptably high risk
SLEP	~20	TBD	

undertaken to evaluate potential materiel solutions, including SLEPs and new aircraft buys.[12]

[12] See Kennedy et al., 2010. This FSA has deferred in-depth analysis of SLEPs and new aircraft buys to the UIAFMA, which is more appropriate for these materiel solutions.