Challenges

21st Century Logistics

Transforming the Aircraft Inspection Process

Compelling reasons exist to radically change the current inspection process. The Air Force's inventory of aircraft has become more geriatric than ever before, leading to increased downtime due to inspections and age-related maintenance factors. Consequently, operating costs for these mature aircraft fleets have soared 83 percent over the last decade.

Because of the projected budget shortfalls, aircraft recapitalization programs will be severely constrained and take 20 years or longer to fully replace their predecessors. As a result, older aircraft will be forced to continue in service to cover the combat capability gaps until the replacement aircraft achieve full strength. Additionally, the cost of replacement weapons systems has become so great that Congress has enacted legislation to prevent the Air Force from retiring aircraft, forcing older aircraft to be flown and be maintained for longer periods to maximize their return on investment.

Overlaid on these factors is the fact that the Air Force has been engaged in combat operations since 1991 and will likely continue to be for the foreseeable future. The combination of high operations tempo, an aging total fleet, and continual personnel reductions makes it imperative for the Air Force to apply Air Force Smart Operations for the 21st Century (AFSO21) concepts to the aircraft inspection process. The threat of terrorism and asymmetric warfare has forced the Air Force to be continually ready to deploy and fight. The Army's transformation and increasingly joint nature of military operations make it imperative for the Air Force to achieve and sustain the highest levels of aircraft availability possible. With the program budget decision-driven manpower reductions, the Air Force cannot continue to carry out the current manpower-intensive inspection requirements and still sustain today's levels of combat capability. The Maintenance Steering Group-3 approach offers the Air Force an opportunity to fully exploit AFSO21 efficiencies to produce combat-ready aircraft with increased availability, reduced cost, and improved unit control through an iterative and responsive inspection construct. Transforming the aircraft inspection process is one approach to produce the efficiencies required to better defend the United States and her allies in the global war against terrorism.

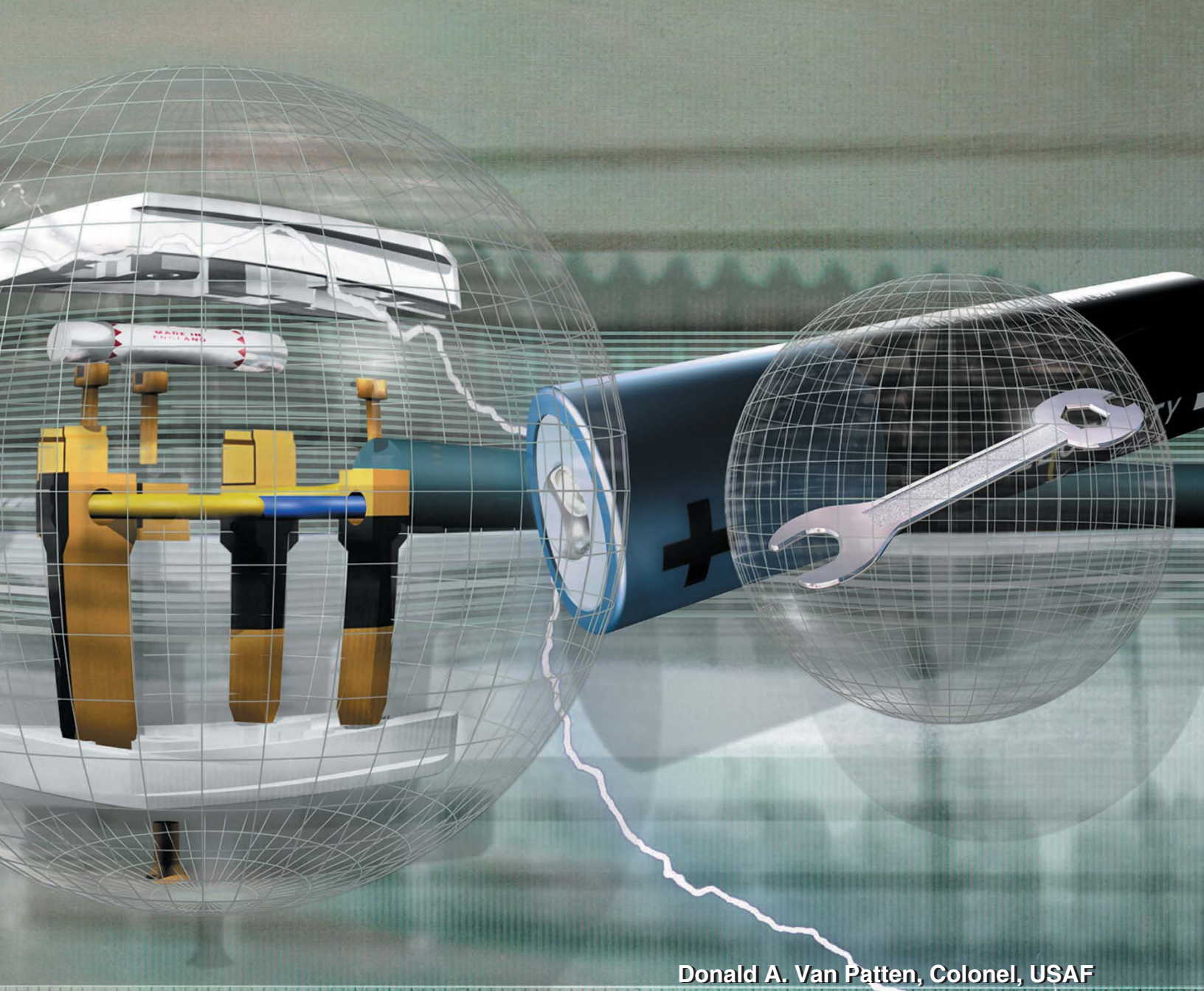
Transforming the Aircr

Introduction

To everything there is a season, a time for every purpose under heaven; … a time to break down, and a time to build up; … a time to keep, and a time to throw away; … a time to keep silence, and a time to speak; … a time of war, and a time of peace.[1]

—Ecclesiastes 3:1-8

The next 5 years promise to bring significant changes to the Air Force's current operating environment. This change is prompted by several budget initiatives to provide funds for vital programs that include recapitalizing the growing inventory of aging aircraft. Some of these initiatives target manpower billets in specific



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aft Inspection Process

areas across the active, reserve, and National Guard forces with a projected goal of reducing full-time equivalent positions by approximately 40,000.[2] One initiative, released as Programmed Budget Decision (PBD) 716, directs the offsets to be fully executed by the end of fiscal year (FY) 2011 across most Air Force specialty codes (AFSCs) in order to minimize huge losses within a few areas. Within the past year, the period to complete the offsets has been accelerated to the end of FY09. PBD 716's impact on aircraft maintenance is to reduce aircraft inspection manpower by 402 billets—a significant decrease in maintenance capability.[3]

The Air Force's plan to reduce the inspection manpower focuses on regionalizing inspection centers for select aircraft types. Although the depot-level overhaul locations would remain unchanged, this plan would eliminate the base-level inspection docks by flying the aircraft to regional sites for their incremental hourly and periodic maintenance inspections.[4]

In addition to the manpower reductions, the Air Force has begun efforts to improve aircraft availability and decrease cost. Faced with decreasing budgets, Air Force leadership established goals to increase aircraft availability by 20 percent and reduce costs by 10 percent.[5] Known as the Aircraft Availability Improvement Program (AAIP), all levels of aircraft sustainment have been directed to develop efficiency initiatives to achieve the PBD goals.[6]

In order to achieve the projected PBD 716 manpower savings of $23.4M over the Future Year Defense Plan (FYDP), there appear to be three viable options. The first option would be to yield the manpower positions while retaining the phase and isochronal inspection docks at their current base-level locations.[7] A second option would be to fully comply with the PBD and regionalize select inspection activities. The last option would be to develop a hybrid alternative—sending aircraft to the regional facilities for heavy inspections, but performing the light checks or minor inspections at the base.

This article analyzes these three options against the goals to increase aircraft availability by 20 percent, while decreasing cost by 10 percent. Additionally, it examines a third impact of these options on a unit's ability to control its success or destiny with respect to mission requirements. As part of the analysis, this study also investigates the theory of reliability-centered maintenance and analyzes its applicability to the inspection options.

Impetus for Change

The Air Force cannot increase aircraft availability and decrease operating costs without revamping the current inspection process. The first of several reasons for change is that the average age of our aircraft today is almost a quarter of a century (23.5 years) and has grown steadily over the past 3 decades. In 1967, the entire fleet's average age was only 8.5 years.[8] This equates to a 176 percent increase in fleet age over the 40-year period. Although the Air Force has started receiving the F-22, the average age of the Air Force's main fighter fleet is still over 20 years. This fact is not insignificant. Because the fleet has become geriatric, it is now susceptible to the normal problems that begin to surface with older airframes. For example, wiring has become a top driver for the F-15C/D. The insulation on the Kapton wiring used widely throughout the fighter aircraft has become brittle and cracked, resulting in an increasing number of electrical shorts and fires. The KC-135 has experienced peeling with its internal fuel tank coatings, leading to contaminated fuel systems and filters.[9] These age-related problems will continue to drive additional aircraft inspections, which in turn, will increase the amount of time the aircraft will not be available for flying.

The second drive for change is increased downtime for the aircraft fleets due to the increased inspections and other maintenance-related aging factors. Over the past 15 years, the amount of aircraft downtime per flying hour has increased and is reflected in the Air Force's maintenance man-hour per flying hour (MMH/FH) ratio metric. For the entire Air Force fleet, this ratio increased 61 percent between FY91 and FY05 (see Figure 1).[10]

This is significant because the Air Force retired some of its oldest fleets of F-4 and F-111 aircraft during this same period without any major impact on the MMH/FH metric. For the aircraft maintenance community, this increase in workload, even with a newer total fleet, is monumental.

Additionally, the size of Air Force budgets has continued to slow at a disconcerting pace over the past several years. Based on current projected budget programs, the FY11 budget will be only 16 percent larger than the FY06 budget—a significant spending departure compared to the previous 6-year period of FY01 to FY06, when the budget grew nearly 44 percent.[11] Due to decreasing budget dollars, the Air Force will be forced to stretch recapitalization plans for replacement aircraft and need to retain older aircraft longer than originally planned to provide the required combat capability.

A fourth impetus for change is the increase in operating costs. Given the volatility of fuel prices, personnel pay and benefit expenditures, and other operating factors that comprise the Air Force total ownership costs (AFTOC), this important sustainment factor promises to rise faster than planned for in the budget requests through FY11.[12] The cost to operate an average aircraft in FY96 was just over $3M. In FY05, the same cost reached nearly $5.5M, an 83 percent increase.[13] This makes the stated AAIP goals even more challenging to achieve.

The last reason for change is the track record of legislative involvement. During the last 4 fiscal years (FY03-FY06), Congress prevented the Air

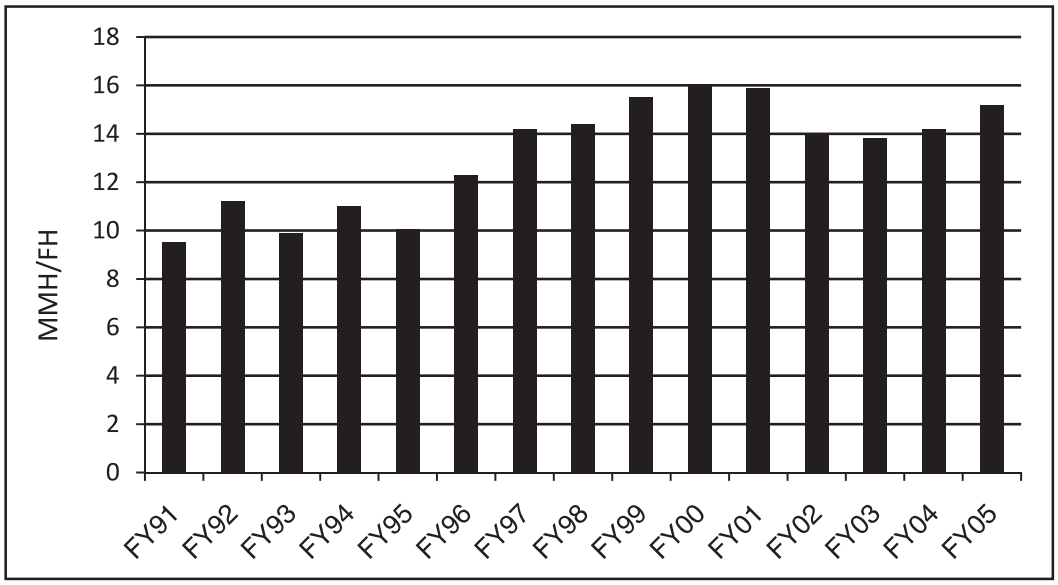

Figure 1. Total Air Force Maintenance Man-Hours per Flying Hour, FY91–FY05

Force from retiring aircraft deemed too costly to operate from the B-52, C-5, C-130E/H, F-117, and KC-135 fleets. As of October 2005, the number of aircraft congressionally restricted from retirement had grown to a total of 104, creating a burden on critical budget dollars.[14] This well intentioned legislation has forced the Air Force to divert shrinking funds from other vital programs to sustain these geriatric weapons systems.

Analysis Criteria and Inspection Types

The types of inspections discussed in this article are limited to the phase and isochronal inspections. The phase-type inspection is determined strictly by the number of operating or flying hours. If an inspection is due at 200 hour intervals, then the aircraft must be inspected at this point before it can be flown further. Aircraft that begin and end their sorties at the same location—such as fighter aircraft—normally operate on the hourly phase inspection concept. Isochronal inspections are based on a specified number of calendar days. Isochronal is a Greek word that means to occur in regular intervals of time.[15] The isochronal intervals are derived from an average number of flying hours that would be accumulated in the interval without degrading safety. The isochronal inspection concept is ideal for aircraft like tankers or airlifters that may fly multiple sorties away from home station. In conjunction with military representatives, the original equipment manufacturers (OEMs) determine the inspection type and intervals during the aircraft's initial operational test and evaluation stage. These types and intervals normally serve the aircraft with minimal change up to retirement.

To sufficiently analyze the data, two aircraft will be examined. Due to their significant numbers and the availability of research data, the phase-interval type F-15C/D fighter aircraft and the isochronal-interval type KC-135 tanker aircraft were selected for this study.

The three proposed options will be evaluated against three criteria: aircraft availability, maintenance operating costs, and unit control. Because having aircraft available for combat and training is a vital prerequisite to enable a unit to accomplish its wartime mission, the Air Force constantly evaluates the aircraft availability of its fleets to identify causes of negative trends. Aircraft availability measures the ratio of time a unit possessed aircraft is mission capable (MC) or mission-ready against the total time of possession by all organizations.[16] The formula used to calculate this rate is as follows:

Availability Rate = (MC Hours/Total Possessed Hours) x 100

An aircraft is considered in possession when it is under its assigned unit's control. For example, if the Air Force had a fleet of 100 aircraft, and in one day 20 aircraft were not MC and 10 aircraft were possessed by depot maintenance, the number of aircraft mission-ready or MC for this 24-hour period would be 70 percent. The calculation would be as shown below:

(70 MC unit possessed aircraft x 24 hours/100 unit and depot possessed aircraft x 24 hours) x 100

Of course, actual aircraft availability calculations are much more complex, as aircraft cycle through only a few of minutes or hours per day of not-mission-capable status before returning to MC status. As stated previously, the Air Force is striving to achieve a 20 percent improvement in availability across all its fleets of aircraft. A major way to impact availability rates would be to decrease the amount of time an aircraft is not mission capable and increase the amount of time an aircraft is unit-possessed and mission capable.

In light of PBD 716's emphasis on cost reduction, the second criterion analyzes the maintenance operating costs across the three options. As stated previously, the AFTOC data base captures the operating expenditures of unit-level consumption, intermediate maintenance, depot maintenance, contractor support, sustaining support, indirect support, and aircraft modifications from program element code (PEC) 3400 – Operations and Maintenance (O&M), and military and civilian pay from PEC 3500 – Pay and Allowances. The aircraft total operating cost is the total annual system costs of the two PECs divided by the total aircraft inventory (TAI).[17] The AFTOC costs most easily influenced at the unit, intermediate (regional), and depot levels are the maintenance and consumables expenditures. Minimizing these costs through a reanalysis of the OEM-developed phase and isochronal inspection construct would directly impact the inspection frequency and workforce size.

The last criterion for judging the effectiveness of the three options is the degree of control a unit retains over its phase and isochronal inspection program. Unit control has always been a foundational building block for maintaining a healthy fleet of aircraft. A flying organization plans and executes its flying hour program with respect to its home station and deployment requirements, exercise and evaluation cycles, contingency rotations, and other local factors, including weather. The integral factor to achieving a successful flying hour program is being able to control the flow and rate at which aircraft are inspected. The inspection process is the banking mechanism for building a savings account of flying hour capability. It is commonplace for a unit to surge its inspection program periodically to respond to an externally-driven mission requirement that necessitates phase or isochronal inspection flexibility in order to accomplish the mission. The Chief of Staff of the Air Force (CSAF) recognized the importance of conjoined authority and responsibility when searching for a replacement to the objective wing structure that divided maintenance authority and responsibility between two groups. Under organizational structures where the maintenance group commander exercises both authority and responsibility for fleet health, aircraft performance has flourished.[18] Separating the phase and isochronal inspection capability from the direct control of the unit, as called for under PBD 716, partitions the necessary authority and responsibility to maintain fleet health in high tempo environments, especially combat and contingency operations. The most recent guidance in Air Force Instruction (AFI) 21-101 states that "Aircraft should not normally deploy with phase or isochronal inspections or engine time changes due immediately upon AOR (area of responsibility) arrival."[19] A unit's direct authority over its aircraft inspection program equates to being able to determine its own destiny or success, especially in combat and contingency operations. Pulling the phase or isochronal capability away from the unit has the strong potential to severely limit its flexibility to match flying requirements with fleet health maintenance.

The MSG-3 Inspection Construct

In the 1960s, an airline industry task force known as the Maintenance Steering Group (MSG) developed a new inspection program, known as MSG-1 (the first report published by the MSG), that produced substantial savings for the Boeing 747 (B747) over the DC-8.[20] Table 1 reflects the savings of the MSG approaches over the traditional approach.[21] In 1970, the Air Transport Association (ATA) led the airline industry in developing a second report (MSG-2).[22] This revised program converted MSG-1 into an inspection logic applicable to aircraft other than the B747.[23]

Interestingly, the preponderance of Air Force aircraft developed during this period utilized the MSG-2 preventive inspection logic. Although these early MSG preventive inspection processes produced huge savings, they were bottom-up approaches that focused on the failures of the individual items versus the effect of failures on the entire system. In addition, these early MSG approaches did not factor in operating performance data as the aircraft matured nor did they establish intervals for the preventive tasks.[24]

To overcome the MSG-1 and MSG-2 shortcomings, the reliability-centered maintenance (RCM) methodology was developed by United Airlines for the Department of Defense (DoD) in 1978. The ATA incorporated this new preventive maintenance program into the revised MSG-3 decision logic published in 1980.[25] The heart of RCM is the failure mode, effects, and criticality analysis (FMECA) which targets components and structures from a top-down systems approach.[26] The effectiveness of RCM is achieved through an *iterative* application of the FMECA throughout the weapons life cycle.[27] Additionally, a predetermined level of system performance and acceptable degradation are established during the analysis, as shown in Figure 2.[28]

The importance of reaccomplishing the FMECA analysis at appropriate intervals cannot be overstated; the cost efficiencies are realized by analyzing performance data on a recurring or iterative basis. Although the terms MSG-3 and RCM are often used synonymously, RCM is the methodology to determine failures and preventive maintenance actions. MSG-3 is the governmental- and industry-sanctioned application of RCM by way of a strong, integrated network of Federal Aviation Administration (FAA), airline operators, and original equipment manufacturer members. The MSG-3 construct allows the operator to adapt and change the inspection program to its particular operating requirements once reviewed and approved by the FAA.[29] The preference to use the MSG-3 term in this article is intentional; MSG-3 connotes responsiveness and receptiveness to change. This is evident in the seven revisions made to MSG-3 from 1987 to 2005 to improve safety and preventive maintenance activities.[30]

Unfortunately, when the Secretary of Defense initiated sweeping reforms to the defense acquisition process in 1994, he also rescinded DoD's mandate to use RCM as well as the numerous Military Standards (MIL-STDs) that provided the methodology to accomplish the analysis. In its place, he mandated the services to rely on industry standards and best practices.[31] This action essentially orphaned legacy equipment, whose extended life cycles need the iterative engineering and operating analysis provided by RCM and the MIL-STDs. This statement is not intended to marginalize efforts by the weapon systems' engineers to improve the inspection continuum. However, constrained resources within Air Force Materiel Command (AFMC) have limited improvements to merely administrative-type changes to the OEM's initial inspection framework.[32]

Consequently, the Air Force's older legacy aircraft now operate on an infantile

Type of Preventive Maintenance	Traditional Approach	MSG-1 & MSG-2 Approach
Structural inspections for 20K flying hours	4M man-hours for DC-8	66K man-hours for B747
Overhaul	339 items for DC-8	7 items for DC-10
Turbine engine overhaul	Scheduled	On-condition (cut DC-8 shop maintenance costs 50 percent)
*Traditional approach to maintenance held that the more frequently equipment was inspected and overhauled, the better it was protected against failure, thus resulting in numerous tasks.		

Table 1. MSG-1 and MSG-2 Savings

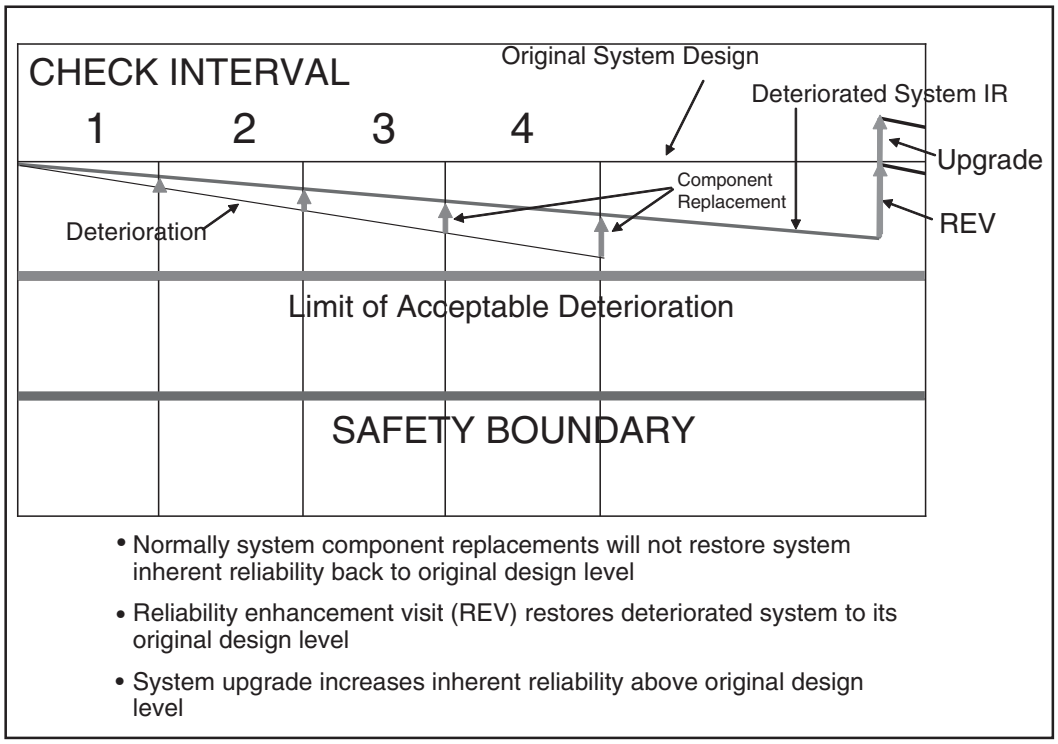

Figure 2. Predetermined Levels of System

preventive maintenance inspection concept primarily developed by the OEMs without having had the benefit of an MSG-3 end-to-end reevaluation of previous decades' systems and structural performance history.

Analysis of Three Options

We must fundamentally change the culture of our Air Force so that all airmen understand their individual roles in improving their daily processes and eliminating things that don't add value to the mission.

—Secretary of the Air Force and Chief of Staff of the Air Force, 7 November 2005

To provide a meaningful analysis of the three options, it is important to examine these alternatives against actual aircraft that are potential candidates for the PBD 716 initiatives. The notional candidate fleets considered for regionalized inspections are the A-10, F-15, F-16, F-22, B-1, B-52, C-130, and KC-135 aircraft.[33] The analysis will be conducted using one aircraft from each inspection construct, the F-15C/D for phase inspections, and the KC-135 for the isochronal construct.

The F-15 inspection construct combines a series of light and medium hourly post flight (HPO) inspections and a major periodic inspection (PE) in a series of 200 flying-hour intervals. For a complete phase inspection cycle, the F-15 undergoes five HPOs and one PE to produce a total of 1,200 flying hours.[34] A complete cycle from the first HPO-1 to the PE entails 3,500 steps, 584 work cards, and 1,001 man-hours.[35] The average time the F-15 fleet was not mission capable (NMC) or not available for flying due to scheduled maintenance (phase inspections) per year during FY97 to FY06 was 2,169,296 hours out of 41,281,421 unit possessed hours, or 5.25 percent.[36] This equates to an average NMC time for phase inspections of 450.1 hours per aircraft per year. Additionally, during the same 10-year period, the availability rate averaged 67.0 percent and the total operating costs from the AFTOC data base averaged $3.676M per aircraft.[37]

The KC-135 uses an isochronal or calendar-based inspection cycle that is accomplished in 360 calendar days. The HPOs occur at day 30, 120, 180, 240 and 300.[38] Additionally, critical corrosion inspections occur at day 180 and 300, along with a mid-PE inspection at 600 flying hours and a major PE during the 300-day inspection.[39] Although the work cards do not provide a standardized timeframe to complete the steps, the average number of HPO and PE work cards and steps per year total 197 and 1,638 respectively. The average time the KC-135 fleet was NMC for scheduled isochronal maintenance during FY97 to FY06 was 2,878,133 hours out of 3,821,265 unit possessed hours, or 75.32 percent.[40] Although this number seems unbelievable, and has been triple checked against the Multi-Echelon Resource and Logistics Information Network (MERLIN) database source, one possible reason for such a high scheduled maintenance rate may be due to the fact that the Air National Guard (ANG) possesses 196 airframes or nearly 40 percent of the total KC-135 fleet.[41] Since the ANG typically works only one shift per day, the doubled time to complete an inspection would contribute to the high scheduled maintenance rate when compared to the unit's time of possession. The average NMC time for isochronal inspections totaled 543.0 hours per aircraft per year during FY97–FY06 and produced an availability rate of 59.9 percent.[42] Additionally, the total operating costs from the AFTOC database averaged $4.184M per aircraft.[43]

Option 1 - Stay the Course

The first option is to continue accomplishing phase and isochronal inspections under the current organizational construct but with a reduction of 402 personnel, as called for in PBD 716. However, instead of the aircraft having its inspection performed at a regional facility, this option calls for completing the inspections at the possessing base. Evenly distributing the 402 manning losses across the Air Force's 73 active duty inspection docks in operation after the projected Base Realignment and Closure-2005 adjustments equates to a loss of 5.5, or 6 whole personnel per dock. As a result, the average F-15 phase dock would drop from 30 personnel to 24 and the average KC-135 isochronal dock from 35 to 29. This loss of manpower equates to an annual loss per inspection dock of 12,096 man-hours (6 personnel x 8 hours per day x 252 O&M work days per year). While it is difficult to measure the exact decrease in aircraft availability that would result under this option, a loss of 6 inspection personnel per F-15 dock would most likely extend the inspection of each aircraft by 1.5 days for HPO-1s, 2 days for HPO-2s, and 2.5 days for PEs. In a 1-year period, a single F-15 unit with 27 assigned aircraft would fall behind the current inspection production rate by 66 days, totaling 1,584 hours of aircraft nonavailability.[44] For the KC-135, the results would be similar. An annual inspection cycle with 35 personnel requires 40 days. Reducing the inspection dock down to 29 personnel would increase the time to complete the annual cycle to 48 days, causing a 12-aircraft unit to fall 96 days behind per year and lose 2,304 hours of aircraft availability. As is evident, this option would negatively impact aircraft availability due to the unit requiring more days to complete phase or isochronal inspections with less manpower. Consequently, the increase in aircraft nonavailability would drive a proportional decrease in possible sorties as well.

Operating costs would obviously decrease with this option due to the PBD-driven reduction in manpower. As the PBD 716 document states, this reduction would provide an annual savings of $58,209 per person, or $23.4M for all 402 technicians.[45] At the unit level, the loss of 6 technicians would equate to a cost reduction of $349,254, thereby positively impacting the cost criterion. However, all other costs would remain the same.

Unit control for this option, the greatest strength of the current inspection approach, remains unchanged. Although the unit will experience a lower aircraft availability rate, it will possess its assigned aircraft the same amount of days as compared to operations before PBD 716. Therefore, this option is judged as having a positive impact on this criterion.

Option 2 - Fully Employ PBD 716 Initiatives: Regionalize Inspections

Fully implementing PBD 716's initiatives, as notionally determined by the Air Staff, would require units within eight aircraft types—A-10, F-15, F-16, F-22, B-1, B-52, C-130, and KC-135—to accomplish all of their phase or isochronal inspections

at regional inspection facilities while reducing the work force by 402 personnel. The concept calls for 10 regional stateside inspection facilities for the Combat Air Forces and four such facilities for the Mobility Air Forces, as shown in Figures 3 and 4.[46]

For overseas-assigned fleets, bases with similar fleets in the same geographical areas would combine their inspections at a single regional inspection site.

Aircraft availability stands to achieve significant increases under this option. One of the improvements in this plan is to standardize the work cards that direct the inspection activities. Currently, almost all aircraft technical order work cards are organized according to the AFSC-tasked inspection and aircraft zone, but not according to the most efficient flow of the inspection. This has led owning organizations to develop their own inspection flow sequencing based on their own requirements and preferences. This lack of standardization across the entire aircraft fleet causes lost time when inspection personnel are rotated among other bases and must learn the new unit's sequencing. Secondly, the locally-developed procedures are not updated promptly, if at all, to incorporate changes due to systems or structural improvements which represents lost efficiencies. Transitioning to a few regional inspection facilities affords the opportunity to conduct an Air Force Smart Operations 21 (AFSO21) study to mitigate these inefficiencies. AFSO21 is the Air Force's model to harness industry process efficiencies to improve operational support and eliminate nonvalue-added work using efficiency tools such as Lean, Six-Sigma, and Theory of Constraints.[47] These improvements would sequence the inspection activities for maximum efficiency and standardize the inspections across the entire fleet. Additionally, a robust training program would be developed to ensure maintenance inspectors fully understood their role in the flow sequencing and the rationale behind it. Early estimates proposed that each aircraft fleet's inspection flow time could be reduced by nearly 50 percent by incorporating these efficiencies.[48] Such reductions would enable the F-15 fleet to decrease scheduled maintenance downtime from a 10-year inspection average of 19 days to 12 days per year.[49] This could potentially add 7 additional days of availability per aircraft per year and up to 14 sorties annually. A similar improvement in isochronal inspections with the KC-135 fleet would decrease scheduled inspection downtime from a 10-year average of 23 days to 14 days per year, leading to 9 additional days of availability and potentially 18 sorties per year.[50] For contingency operations, four additional deployable docks, two at each stateside regional site, would provide the capability to perform inspections at deployed sites. Aircraft availability under this second option would improve significantly. The rationale for such a prediction is based on the process efficiencies of restructuring the inspection flow for each aircraft.

Costs for this option would be similar to those of the first option—reduced primarily due to the loss of 402 personnel, providing a savings of $23.4M. However, these savings would be offset by onetime costs, as shown in Table 2.[51] Expenses to relocate the remaining 1,020 of 1,555 inspection personnel to

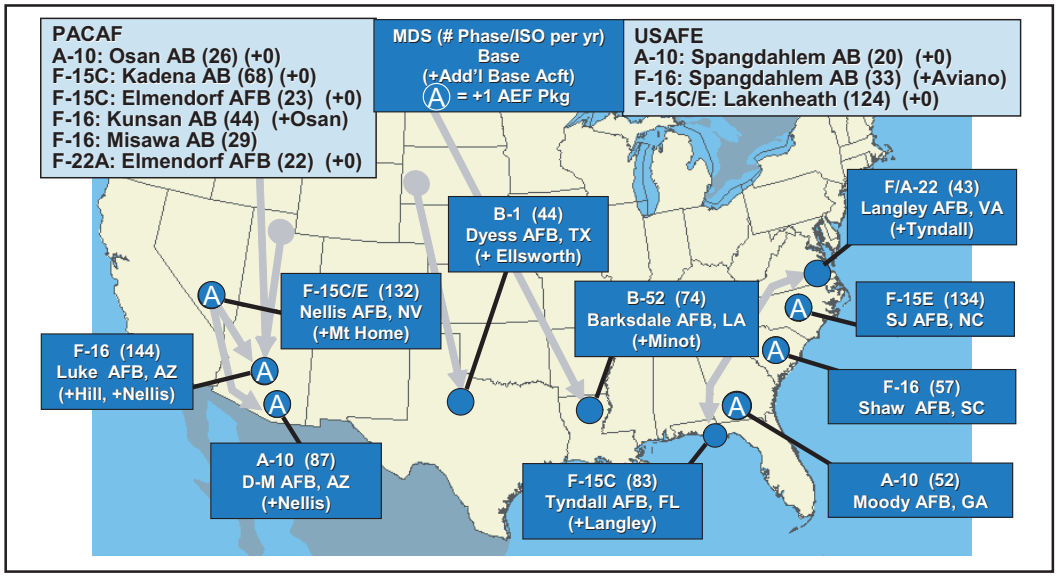

Figure 3. Option 2 Regional Inspection Concept—Combat Air Forces

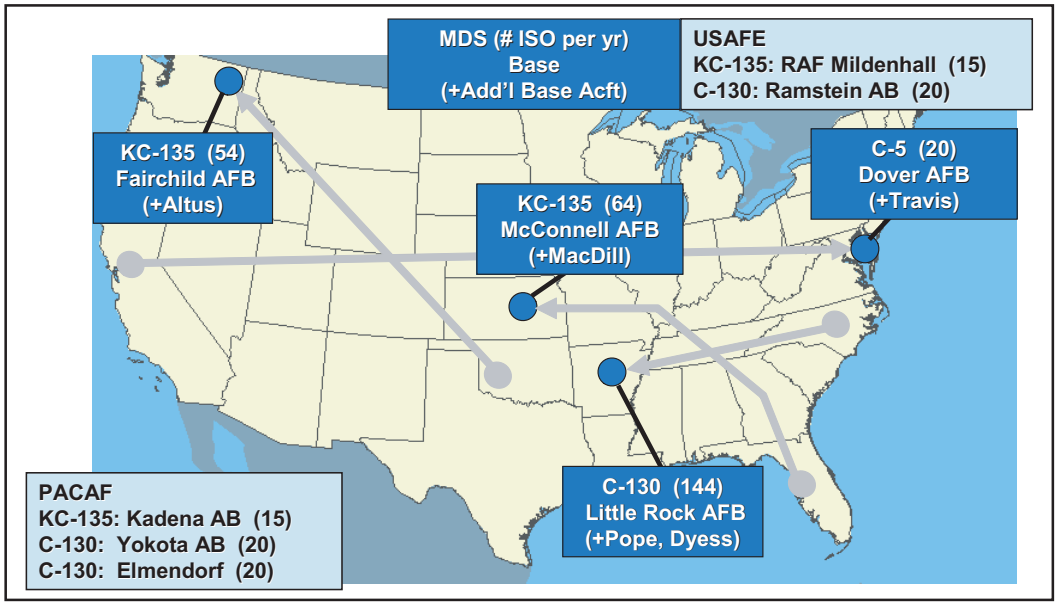

Figure 4. Option 2 Regional Inspection Concept—Mobility Air Forces

their respective regional inspection centers, as well as fuel and travel costs incurred in ferrying the aircraft to and from the regional inspection facilities, would offset the savings. Achieving maximum benefits through an AFSO21 review would require assistance by experienced consultants. A projected $300K cost to implement the new concept at each of the 27 stateside and overseas regional sites would total approximately $8M; a cost well worth decreasing inspection flows by half.[52] An additional cost of $130K to relocate special equipment, hardware, and other assets per fleet would add $1.04M.[53] Despite these costs, a total projected annual savings of nearly $12M would accrue, excluding personnel relocation and aircraft ferry costs.

Unit control under this option would be the factor most significantly decreased. Current inspection operations allow the unit to determine their phase or isochronal production rate to meet internal and external flying requirements. This flexibility provides a critical buffer to balance mission requirements with maintenance capacity. Internally, a unit will increase or decrease the number of inspections based on the flying hour program, sometimes phasing multiple aircraft simultaneously to yield short periods without any aircraft undergoing inspection. This approach has been a critical unit tool to support periods needed to upgrade pilots to four-ship aircraft flight lead prior to deployments or exercises. Additionally, units often preload their inspections to fly sortie surges. For example, an F-15C fighter squadron recently set a world record for the number of sorties during a 3-day surge—a feat not likely under a regional inspection concept.[54] In addition, external real-world mission requirements, such as short-notice contingency operations and deployments, would also be difficult to execute without being able to change inspection priorities or production rates. Prior to an air and space expeditionary force (AEF) rotation overseas, fighter units will typically increase or even surge their inspection production rate to amass enough inspections hours so that the unit doesn't need to accomplish any inspections immediately upon arriving in-theater. This surge enables the unit to have sufficient spare aircraft available with adequate remaining inspection hours.

Weather would also potentially impact the flow of aircraft inspections through a regional facility. Flying units normally attempt to maximize aircraft availability during the good months of summer flying—counterproductive to establishing a smooth fleet flow and maximizing capacity under the regional inspection dock concept. Consequently, during months of poor flying weather, the regional facilities would not have enough capacity to inspect the required number of aircraft. The regional inspection construct would require a highly responsive scheduling function in order to provide the same degree of flexibility. Finally, with inspection docks located miles away rather than just off the flight line, opportunities to cannibalize critical parts to generate sorties would be lost.

This option would improve the flow days through an efficiency study, standardized inspection technical orders, efficiently sequenced actions, and a highly skilled and trained work force. These positives would be offset by the other factors that would restrict flexibility at the unit level. The unit's ability to prepare for AEF commitments, sortie surges, and weather-driven issues, as well as respond to no-notice contingency operations, periods of low aircraft availability, time compliance technical orders (TCTO), other preventive maintenance, and pilot-training requirements would be more limited and only serve to defeat mission accomplishment. In a perfect world, this alternative would be an optimal solution; however, equipment, weather, and human requirements demand more flexibility not inherent in this option.

Inspection Dock Calculations		
	Before	After*
A-10, F-15, F-16, F-22	50	29
B-1, B-52	7	4
KC-135	6	4
C-130	10	7
Total	73	44
* Based on 50 percent inspection flow reduction; does not take credit for BRAC		
Inspection Personnel Calculations		
Post-BRAC/Pre-Regional Personnel: 2,033		**After**
A-10, F-15, F-16, F-22	(30/dock x 29 docks) _ (30/dock x 6 AEF docks)	1,050
B-1, B-52	30/dock x 4 docks	120
KC-135		140
C-130		245
Total		1,555

Cost Calculations (in $M)							
1st FY = AFSO21 training/contractor and reorganization per MDS site = $0.30M							
2nd FY = Regionalization/relocate assets per MDS = $0.13M							
Aircraft	**Sites**	**FY07**	**FY08**	**FY09**	**FY10**	**FY11**	**Total**
F-16	5	$1.50	$0.13				$1.63
C-130	4	$1.20	$0.13				$1.33
A-10	4		$1.20	$0.13			$1.33
KC-135	4		$1.20	$0.13			$1.33
C-5 **	4			$0.30	$0.13		$0.43
F-15C/E	6			$1.80	$0.13		$1.93
B-52	1			$0.30	$0.13		$0.43
B-1	1				$0.30	$0.13	$0.43
F-22	2				$0.60	$0.13	$0.73
Total		$2.70	$2.66	$2.66	$1.29	$0.26	$9.57

Table 2. Option 2 Notional Implementation Costs

Option 3 - Hybrid Solution

Whereas the first and second options are merely administrative changes (improvements within an existing construct), the third option changes the model by employing RCM and MSG-3 concepts to their maximum extent. First, the entire inspection continuum requires a top-to-bottom reevaluation using the analysis developed under MSG-3. Drawing on the operational systems performance data already being collected, engineers could reevaluate the FMECA for each type of aircraft and realign the inspections into intervals based on the new failure projections, establishing preventive tasks as required based on the analysis. The MSG-3 construct facilitates shifting the most time-consuming, major structural inspections to the heavy PE inspections later in the phase or isochronal cycle, which allows the light-to-medium HPO inspections to concentrate on systems reliability.[55] These minor inspections can be packaged into 6-hour segments and completed during nonflying periods of the day or week at the aircraft's assigned base. Therefore, aircraft would only need to be flown to the regional inspection facility for PEs requiring more rigorous repairs or refurbishment not possible at the home station.

By employing MSG-3 on their Boeing 737 (B737) fleet of 447 aircraft, Southwest Airlines has been able to sustain over 3,050 flights daily with 435 of their aircraft. This equates to 97.3 percent of their fleet dedicated to the daily flying schedule. Southwest Airlines accomplishes all of their light and medium inspections overnight at airports and their heavy inspections at one of three regional locations. Using the MSG-3 model, Southwest Airlines anticipates each B737's 30-year life span will only require 82 days of downtime for scheduled inspections, resulting in a 99.97 percent aircraft availability rate throughout the aircraft's life span.[56] Annually, this downtime averages 2.73 days, or 0.7 percent, per aircraft.

Analyzing this hybrid option against the aircraft availability criterion would produce the greatest benefits by far. While no US military examples of a total conversion to an MSG-3 approach exist, AFMC has begun an MSG-3 conversion study for the C-5 fleet. The realignment of newly developed inspection tasks lengthened the 105-day, 420-day, and 840-day isochronal inspections to 120, 480, and 1460 days, respectively.[57] The net effect is to increase C-5 fleet aircraft availability by 5 aircraft per year, a 4.5 percent increase in aircraft availability.[58]

Applying the MSG-3 construct to the F-15 inspection continuum would allow the preponderance of structural inspections to be accomplished during PE checks. Consequently, HPOs could be limited to systems inspections and packaged into smaller segments that could be accomplished across several days during nonflying periods. For example, currently an F-15 averages 450 hours per year undergoing scheduled phase inspections.[59] The complete F-15 phase cycle takes approximately 5 years to complete, averaging 94 days of scheduled downtime per aircraft during that period. Because PEs require 10 days out of this entire cycle, the ability to be able to accomplish all HPOs on the ramp would add 84 days of aircraft availability over 5 years, or nearly 17 days per year for each F-15. The total extra days of availability across the fleet of 482 aircraft would be the equivalent of gaining 17 additional F-15s per year and equates to a 4.6 percent increase in aircraft availability.[60] For FY06, the availability rate of 68.7 would have increased to 73.3 percent, surpassing the Air Force goal of 68.5 percent.[61] While it is unrealistic to assume that the aircraft would remain mission capable during the HPOs, estimating a 25 percent nonmission capable time during the inspections would still yield an additional 17 aircraft per year and a 3.5 percent increase in availability.

The KC-135 fleet would likewise benefit from an MSG-3 analysis and inspection approach. Over a 10-year period, each KC-135 was unavailable for an average of 23 days a year due to scheduled isochronal inspections.[62] The KC-135 is required to complete an entire isochronal cycle of six inspections within 12 months.[63] Assuming that five of the six light and medium HPOs consume 13 days and the sixth heavy PE accounts for 10 days, the MSG-3 reevaluation would repackage inspection tasks into 6-hour segments. This would allow the light and medium HPOs to be conducted at the base, while the heavy PEs would occur at a regional inspection facility. Consequently, each KC-135 could be available 13 additional days per year, increasing the fleet availability rate by 3.5 percent. The total extra days of availability across the fleet of 530 aircraft would be the equivalent of gaining nearly 19 additional KC-135s per year, equating to an increase in availability from 61.4 to 64.9 percent for FY06, surpassing the Air Force goal of 61.4 percent.[64] Assuming a similar 25 percent nonmission capability during the minor inspections would still yield 14 additional aircraft and a 2.9 percent availability rate increase.

Of course, this hybrid option is not without significant costs. Conducting the MSG-3 analysis requires a substantial investment in time, resources, and personnel. However, one aviation maintenance expert predicts "conversion to an MSG-3 based maintenance schedule will provide significant and tangible returns [with] as much as a 30 percent reduction in scheduled maintenance costs."[65] For the C-5 fleet, AFMC has invested approximately $7M to date to standardize historical performance data and conduct a complete FMECA evaluation of all the aircraft's systems.[66] This effort began in 2002 with a staff that included engineers, analysts, systems technicians, maintenance overhaul representatives, OEM representatives, flight crews, and quality assurance personnel.[67] Their strategic intent was to reduce costs and increase aircraft availability by increasing inspection intervals without compromising safety.[68] These goals have yielded a cost avoidance of 32 percent for the C-5As and 5 percent for the C-5B fleet through the interval changes.[69] Although the finalized cost data has not been fully tabulated, the cost avoidances are in the multimillion dollar range due to the inspection interval changes.[70]

Applying a similar percentage based on the C-5's financial gains against the two test case aircraft would most likely yield similar investment costs and cost avoidances due to the MSG-3 efforts. If a modest 10 percent cost avoidance factor were applied to the F-15 unit-level consumable costs, the annual savings could amount to $9.46M per year (10 percent of the average costs during FY97-FY06).[71] However, an estimated cost to conduct the MSG-3 study for the F-15 fleet could total as much as $10M. Amortizing the $10M cost of the MSG-3 study across the entire fleet of 482 aircraft would amount to a onetime investment of $20,750 per aircraft. The net savings across the FYDP of 5 years would include the $10M MSG-3 study cost and the $47.3M cost avoidance in unit-level consumables, yielding a net FYDP savings of $37.3M.

If the same modest 10 percent cost avoidance factor were applied to the KC-135 unit-level consumable costs, the annual savings could reach $8.28M (10 percent of the average costs during FY97–FY06).[72] As with the F-15, accounting for the $10M investment to conduct the MSG-3 study across the fleet of 530 KC-135s would produce a cost per aircraft of $18,870. The net savings across the FYDP would include the $10M MSG-3 study cost and the $41.4M cost avoidance in unit-level consumables, yielding a net FYDP savings of $31.4M.

Moreover, this hybrid option would accrue the $23.4M savings projected from the reduction of 402 personnel due to the PBD 716 manpower cuts. However, rather than moving all remaining 1,555 inspection personnel to regional facilities, only a percentage would be required at the central inspection sites, due to the MSG-3's lengthened intervals for heavy inspections. Therefore, a greater percentage of inspection personnel could remain within their unit to assist with the onsite light and medium inspections. Furthermore, the inspection personnel would be assigned to the sortie generating squadron so that they could form the inspection cadre to accomplish the light and medium checks, train other flight line personnel in these duties, and contribute to sortie generation activities during slack inspection periods. Because of the realignment of inspection tasks and lengthened intervals, fewer aircraft would flow through the regional inspection facilities. Assuming that the heavy PE inspections would account for one-sixth of all current base-level inspections, as is the case with the F-15 and KC-135, then just one-sixth of unit inspection personnel would need to be assigned to the regional facility. Even if 20 percent of the 1,555 inspection personnel were required to perform the heavy PEs, only 311 personnel would need to be relocated to the regional sites—a substantial cost savings compared to Option 2's requirement to move all 1,555.

Finally, unlike under Options 1 and 2, the hybrid alternative maximizes unit control of assigned aircraft. This option enables the unit to conduct its light and medium inspections at the base using the MSG-3 approach. Being able to break inspections into small, 6-hour blocks enables a unit to more readily control the inspection flow to better meet unforecasted requirements, taskings, and AEF deployment demands. Furthermore, the unit still retains the inspection personnel who can deploy with them to the AEF location to ensure that inspections are accomplished during the deployment. These benefits are simply not available under the regionalized concept of Option 2.

Summary and Implementation Considerations

This chapter has examined three options for allowing the Air Force to perform phase and isochronal inspections with 402 fewer personnel. Option 1 retains the current inspection concept of performing the inspections at the base but with 402 fewer personnel. Unfortunately, with less manpower to complete inspection tasks under the current construct, inspection time would increase, causing aircraft availability to decrease. Option 2 sends all aircraft to a regional inspection facility. As compared to Option 1, this option would improve aircraft availability but would require implementation expenditures and significantly degrade a unit's flexibility to accomplish mission requirements and thereby control the health of its fleet.

Option 3 provides a hybrid solution that significantly improves both aircraft availability and unit control. This option requires approximately $10M per aircraft fleet, or $80M across the Air Force's eight aircraft types, to conduct the failure analysis and to determine the inspection task packaging for the MSG-3 approach. The initial investment is minimal when compared to the gains. When analyzed against the F-15 and KC-135 fleets, the MSG-3 approach offers the equivalent of gaining 31 additional aircraft per year from both fleets. This option packages the minor inspections into 6-hour segments that can be accomplished overnight or between sorties by personnel assigned to the sortie generating unit who can continue the inspection rhythm at home station or deployed to a combat environment. Consequently, the unit to which the aircraft are assigned retains both responsibility and authority for the health of their fleet. Pride of ownership, as General Wilbur Creech demonstrated with the dedicated crew chief program during his tenure as commander of Tactical Air Command, is not inconsequential for maintaining and improving aircraft readiness levels. Additionally, Option 3's plan to fly the aircraft to a regional inspection facility for the heavy, structure-focused inspections leverages the regional experience and industrial-type test and repair equipment not found at the base level.

Most importantly, by fully supporting the most significant Army restructuring in the last 50 years, Option 3 offers significant benefits for Joint operations. In keeping with their emphasis on expeditionary, brigade-sized organizations, the Army is eliminating 36 heavy field artillery units, 10 air defense units, and 19 armor units to build military police, civil affairs, psychological, and biological detection units.[73] As a result, the Army will fully rely on the Air Force and the other Services to provide their artillery fire support through improved precision attack munitions. Option 3's opportunities for increased aircraft availability and unit control establish the foundation for the Air Force to better shoulder this Joint fire support responsibility and increase its relevance in the Joint arena. Even though the savings for Option 2 are greater in the short term, Option 3 provides hundreds more airframes across the entire fleet every year; a long term increase in aircraft availability that more than justifies the initial additional investment. In today's environment of Joint interdependency and constrained aircraft recapitalization, the low-risk, high-yield dividends demand serious consideration of Option 3. Table 3 summarizes the key aircraft availability, cost, and unit control data for the F-15 and KC-135 test cases.

To implement a vigorous MSG-3 reevaluation across the eight or more weapon systems candidates, several actions need to be taken. At the Air Staff level, policy and sufficient funding must be established for conducting the MSG-3 review and analyses. The process needs to be formalized, with standardized guidance for mandatory participants [Headquarters United States Air Force, major commands (MAJCOM), system program offices (SPO), and others] regarding responsibilities, time lines, and funding requirements. A decision and approval process for initiating and conducting subsequent iterative MSG-3 reevaluations needs to be established. The lead MAJCOMs for the candidate aircraft need to partner with the SPOs to standardize the inspections flow for the most efficient sequence, devise user-friendly, industry-standard type work cards to improve technician efficiency, and fund AFSO21 consultants to outline the most efficient way ahead. Additionally, the commands must develop acceptable levels of

COMPARISON OF THE THREE OPTIONS						
	Option 1 Stay the Course		Option 2 Regionalize Inspections		Option 3 Hybrid MSG-3 Solution	
	F-15	KC-135	F-15	KC-135	F-15	KC-135
Aircraft Availability (AA)	Decreases 1,177 days* (Equiv of 4 less F-15s/yr; -0.7% AA)	Decreases 4,240 days* (Equiv of 12 less KC-135s/yr; -2.2% AA)	Increases 3,374 days* (Equiv of 9 more F-15s/yr; +1.9% AA)	Increases 4,770 days* (Equiv of 13 more KC-135s/yr; +2.7% AA)	Increases 6,146 days** (Equiv of 17 more F-15s/yr; +3.5% AA)	Increases 5,167 days** (Equiv of 14 more KC-135s/yr +2.9% AA)
			Additional Investment of:		Additional Savings of:	
Operating Cost	No additional savings above $23.4M FYDP Manpower Savings for all Air Force Fleets		$1.93M in FYDP	$1.33 M in FYDP	$37.3M*** In FYDP; $9.46M/FY Thereafter	$31.4M*** In FYDP; $8.28M/FY Thereafter
Unit Control	Retain in Status Quo Approach		Significantly Decreased in Regionalization Approach		Retained in MSG-3 Approach h	

*** Increases/decreases are calculated across the entire fleet of 482 F-15 and 530 KC-135 aircraft.**
**** Accounts for assumed 25% nonmission capable status during light and medium inspections.**
***** FYDP savings deducts the one-time $10M investment for the MSG-3 study; annual savings; thereafter would be based on 5-year savings of $47.3M (F-15) and $41.4M (KC-135).**

Table 3. Comparison of the Three Inspection Options

system degradation and formalize them in a revised minimum essential systems list (MESL) to balance mission requirements against sustainment costs. Along with these changes, the new inspection process must be gradually phased in, allowing pilot units to test and refine the new system before employing it across the fleet. Finally, units need to set up training programs for their inspection personnel and employ AFSO21 consultants to assist in transitioning to the new MSG-3 inspection construct. These recommendations would create the type of responsive and predictive inspection environment that would produce improved aircraft availability and reliability with decreased operating costs.

Conclusion

As the author of the Bible verse in Ecclesiastes observed, there is a time for everything, including change. The budgetary decreases across the next several FYDPs mandate that the Air Force reexamine all of its current processes. Driven by the manpower cuts dictated in PBD 716 and 720, the time for changing aircraft inspections is now. Increasing aircraft availability while decreasing operating costs without sacrificing combat capability requires more than mere administrative changes to the Air Force's current phase and isochronal inspection processes.

Compelling reasons exist to radically change the current inspection process. The Air Force's inventory of aircraft has become more geriatric than ever before, leading to increased downtime due to inspections and age-related maintenance factors. Consequently, operating costs for these mature aircraft fleets have soared 83 percent over the last decade.[74]

Because of the projected budget shortfalls, aircraft recapitalization programs will be severely constrained and will take 20 years or longer to fully replace their predecessors. As a result, older aircraft will be forced to continue in service to cover the combat capability gaps until the replacement aircraft achieve full strength. Additionally, the cost of replacement weapons systems has become so great that Congress has enacted legislation to prevent the Air Force from retiring aircraft, forcing older aircraft to be flown and be maintained for longer periods to maximize their return on investment.

Overlaid on these factors is the fact that the Air Force has been engaged in combat operations since 1991 and will likely continue to be for the foreseeable future. The combination of high operations tempo, an aging total fleet, and continual personnel reductions makes it imperative for the Air Force to apply AFSO21 concepts to the aircraft inspection process. The threat of terrorism and asymmetric warfare has forced the Air Force to be continually ready to deploy and fight. The Army's transformation and increasingly joint nature of military operations make it imperative for the Air Force to achieve and sustain the highest levels of aircraft availability possible. With the PBD-driven manpower reductions, the Air Force cannot continue to carry out the current manpower-intensive inspection requirements and still sustain today's levels of combat capability. The MSG-3 approach offers the Air Force an opportunity to fully exploit AFSO21 efficiencies to produce combat-ready aircraft with increased availability, reduced cost, and improved unit control through an iterative and responsive inspection construct. Transforming the aircraft inspection process is one approach to produce the efficiencies required to better defend the United States and her allies in the global war against terrorism.

Notes

1. Ecclesiastes 3:1-8, *The Holy Bible, New King James Version*.
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4. Aircraft initially proposed by Headquarters USAF/A4MY in Fall 2005 as potential candidates for regionalized inspections were the active duty A-10, F-15, F-16, F-22, B-1, B-52, C-130, and KC-135 fleets.
5. Lt Gen Donald Wetekam, DCS/Installations & Logistics, HQ USAF/A4, and Lt Gen Richard Reynolds, Vice Commander, HQ AFMC to directors of logistics at HQs AMC, AFMC, ACC, and AFSOC, letter, 8 April 2005. This letter directed the 20 percent aircraft availability by FY11. Later, HQ USAF/A4M and HQ AFMC/A4 included the 10 percent cost reduction effort in the August 2006 AAIP.
6. Col John Stankowski, Chief, Weapons System Division, HQ USAF/A4MY, Briefing, subject: eLog21 - AAIP, 1 December 2006, slides 3-25. The AAIP was formed in April 2005 to improve depot overhaul efficiency and parts processes for 20 aircraft fleets.
7. Department of Defense, *Program Budget Decision 716: Directed Offsets - Air Force*, 2.
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18. Gen John Jumper, Chief of Staff (CSAF), Headquarters USAF, "Wing Organization Evolution, 1947-2002," briefing, 21 February 2003, slide 37.
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20. Dave Nakata, "Why Transition to a MSG-3 Based Maintenance Schedule?," EmpowerMX White Paper, [Online] Available: http://www.empowermx.com/whitepapers/MSG3.pdf, accessed 12 December 2006.
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    The ATA is the principle trade organization of major US airlines, OEMs, and other airline-related businesses.
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33. Colonel Schumacher, "Enterprise View of Aircraft Inspections," briefing, slides 36-37.
34. The complete cycle for an F-15 phase inspection requires an HPO-1, HPO-2, HPO-1, HPO-2, HPO-1, and PE to produce 1,200 phase hours. The HPO-1 contains 494 steps in 77 separate work cards, totaling 120 man-hours. The HPO-2 includes the HPO-1 inspection items and comprises 673 steps in 114 work cards and nearly 201 man-hours to complete. The PE includes both HPOs, has 705 steps in 125 work cards, and requires 239.4 man-hours to complete.
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50. *Ibid.*
The 14 days of scheduled maintenance downtime includes 2 days required to deliver the aircraft to and from the regional site.
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52. *Ibid.*
53. *Ibid.*
54. Author's personal experience while assigned as the squadron maintenance officer, 60th Fighter Squadron (FS), 33rd Fighter Wing (ACC), Eglin AFB, FL. The 60 FS made Air Force history in 2000 by flying 130 sorties in a single day and 362 over 3 days; eclipsing the world record by 18 sorties for 1-day and 37 sorties for 3-day flying windows.
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56. Author's discussion with Gregg Brown, Manager, Regulatory Compliance, Southwest Airlines), 23 February 2006.
57. Scott Vandersall, "MSG-3," briefing, slide 12.
58. Scott Vandersall, "MSG-3," briefing, slide 57.
59. Scott Finley, REMIS - USAF, Scheduled Maintenance Downtime for F-15 and KC-135 Aircraft.
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61. Air Force Portal, Applications: MERLIN, Mission Performance, Weapon Systems Availability for F-15A-D, FY97-FY06, 29 January 2007, and MERLIN, Readiness Review, 12 December 06, slide 3, [Online] Available: https://www.my.af.mil/merlinprod/MissionPerformance/mission_WSA_unit.asp, both accessed 29 January 2007.
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68. Scott Vandersall, MSG-3, 22.
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For Want of a Spanner

A curious minor logistical mystery of Royal Air Force History in World War II was the shortage of hand tools. This lasted well into 1943, four years after the war began and nine years after rearmament started in 1934.

Before wartime expansion, fitters and riggers did their initial course at No. 1 Technical Training School at Habton. They specialized either as engine fitters or as airframe riggers. Upon completion of the course, they were sent to squadrons where in seven years their education was completed.

At the squadron they reported to A, B, or C Flight where they were issued a toolkit. If they were transferred from one flight to another, they had to turn in their toolbox and have the contents accounted for before proceeding across the street to draw another set from their new flight. In biplane days, a fitter or a rigger assigned to a two seater not only acted as the gunner, but in colonial theaters lashed his toolbox to the wing next to the fuselage in case of a forced landing.

What makes the case of the missing hand tools so intriguing is that the historical documentation concerning the ordering of such necessary items has disappeared (meaning it has either been destroyed or it has been filed with the papers of a successor organization of unlikely title).

The first clue to the problem came from the Operational Record Book (ORB) of a repair and salvage unit (RSU) in the Middle East in 1940 which opened by noting that of the RSU's 62 personnel, only 25 had tools. So they were happy to pass on salvaged aircraft to whoever claimed them.

What this meant was that in a theater then desperate for serviceable aircraft, many were standing idle because the necessary repairs could not be made *for want of a spanner*, let alone the necessary spares.

But the matter is important because in 1943 in Burma (South-East Asia Command or SEAC), the Beaufighters of No. 26 Squadron only sortied once every 18 days due to lack of tools and spares.

The fact that the RAF had insisted on standardized nuts, bolts and other fittings meant that special tools were not needed. Unserviceability was due to the unavailability of regular tools.

Robin Higham, PhD

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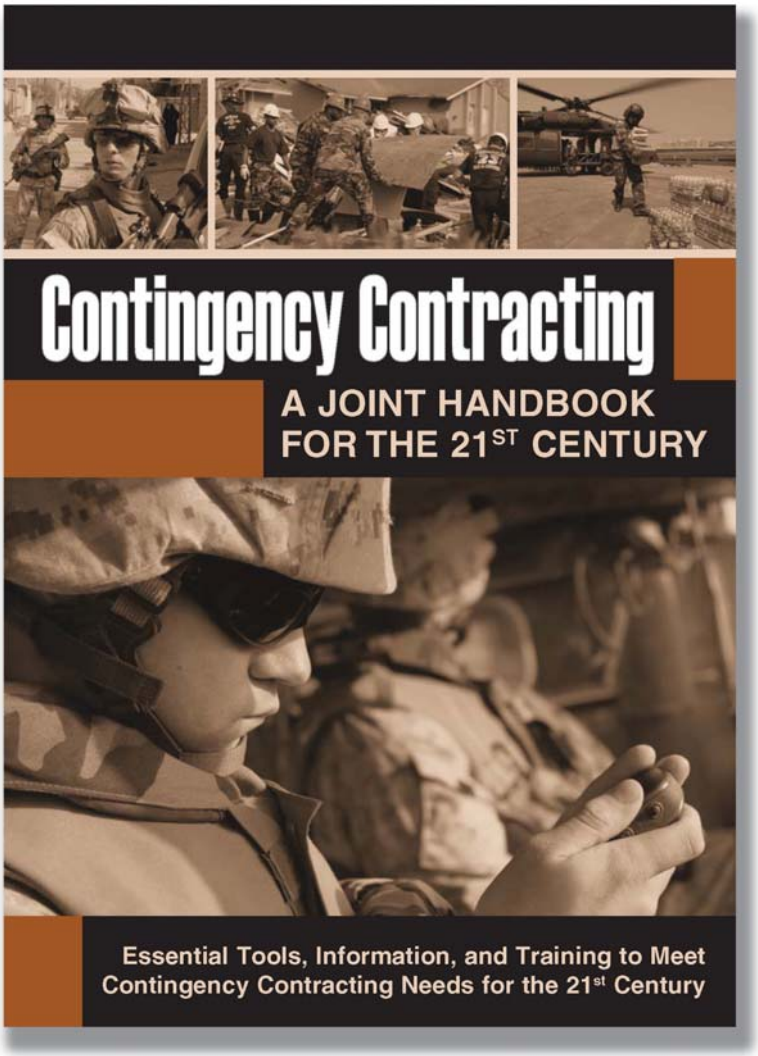

Contingency contracting support has evolved from purchases under the simplified acquisition threshold to major defense procurement and interagency support of commodities, services, and construction for military operations and other emergency relief. Today, this support includes unprecedented reliance on support contractors in both traditional and new roles. Keeping up with these dramatic changes, while fighting the Global War on Terror, is an ongoing challenge.

This pocket-sized handbook and its accompanying DVD provide the essential information, tools, and training for contracting officers to meet the challenges they will face, regardless of the mission or environment.

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Generating Transformational Solutions Today; Shaping the Logistics Enterprise of the Future